Engineering Record

A Weekly Journal Devoted to Civil Engineering and Contracting

Published by The McGraw Publishing Company, Inc.

Volume 69 NEW YORK, SATURDAY, JANUARY 3, 1914 Number 1

Outlook for 1914

WHILE the business tone in the latter half of 1913 was distinctly dull and pessimism was rampant, the prospects have so changed that an attitude of hope has succeeded that of discouragement. In general, only a moderate year is expected, but this does not apply to public works. Municipalities have little trouble disposing of securities, as compared with private corporations, and consequently the volume of highway, pavement, sewerage and water-supply work is not expected to suffer. In highway work, particularly, a good year is expected. The passage of the tariff and currency acts has had a favorable effect upon the general attitude—not that the laws have been unanimously approved but because the settlement of these problems removes some of the uncertainties which have forced business to assume a conservative position. As to the currency measure, the disposition of the bankers is to give a fair trial, realizing that whatever its shortcomings it contains so much of good that it is certain to have a favorable influence on business conditions. However, the uncertainties have not all been removed. Nevertheless, there is a disposition to accept the President's assurances that the anti-trust and other legislation which is to come will not be disturbing to corporations operating within the Sherman law. One reason for the growing optimistic tone is the belief that the Interstate Commerce Commission will grant the railways the increased freight rates for which they have prayed. No other government act could more certainly restore public confidence than this. Taken generally, therefore, there is no reason for discouragement. Few even among the chronically pessimistic believe that conditions will grow any worse, while fair observers are confident that we have passed the ebb and that the tide of prosperity will steadily continue to rise.

Review of the Year

WITH this number is established a custom, new to this journal, of publishing a review of the year. The close of one year and the beginning of a new naturally invites a survey of past accomplishments and a forecast, or, at least, the formulation of hopes as to the future. Each of the specialists who have contributed to the review is in sympathy with this view, and the contributions, therefore, while mainly retrospective, also look to the future. On account of the standing of the authors their views as to the lines along which the immediate future developments will probably proceed deserve more than ordinary consideration.

New Typographical Dress

WITH this issue the Engineering Record assumes a new typographical dress. The aim has been to select a stronger type face—one that could be read with greater ease. The selection was made only after careful investigation and conference with experts in typographical matters. Simultaneously with this change the first part of the Current News Section is also set in larger type. For somewhat over a year special efforts have been made to develop the news columns of this journal. As a result this has become one of the most widely read sections of the paper. The larger type will not only conduce to the physical comfort of the readers but will give this section the dignity which its importance deserves. It is a warrant, too, that the efforts which have been expended on the gathering and presentation of current news will be increased in the future, in order that this department may become even more serviceable.

The St. Paul and Direct Current

ON page 29 of this issue are further details regarding the electrification of the Chicago, Milwaukee & St. Paul. Railway officials will note with regret that the most important facts—the reasons for adopting the direct-current system—are missing. While appreciating fully the value to the railway company of such studies as may have been made, one cannot restrain the feeling that in so controversial a matter there is an obligation to give the reasons for the choice—not that there may be more controversy, but that others having similar problems to face may profit by the experience of each investigator. All scientific advancement comes by starting with the proved data of predecessors. To cover again all the ground worked over by the St. Paul on the subject of electrification would be parallel to starting the design of a hydro-electric plant by investigating the laws of gravitation. The Chicago, Milwaukee & St. Paul can render a great service to the railways of the country and to the engineering profession by disclosing the reasons for its choice and the data on which they are based. The company is too big and broad to do otherwise.

Helping to Safeguard Life

"DO IT NOW!" is the heading of an editorial in the "Milwaukee Free Press" of Dec. 17 urging the closure of six lodging houses which, although condemned by the building inspectors, were not closed; neither were they required to right the unsatisfactory conditions until the beginning of the new year. The writer in the "Free Press" held that as the dangerous conditions had undoubtedly existed for some time it was all the more important that they be corrected at once. He pointed to the danger of disaster from inadequate provisions for safety—a danger greatly augmented at the present time by the congestion due to the large number out of employment. Of this danger the country has had vivid demonstrations in the recent lodging-house catastrophes in Boston and Cincinnati. As noted in these columns two weeks ago, engineers should not wait "until the old bridge falls" before taking to heart rigid inquiry into existing conditions. It is certainly encouraging to technical men to have the daily newspapers emphasize the importance of timely action when the circumstances are known. Too often they look only at the spectacular while it has news value and fail to follow the matter when constructive expert opinions are available.

Bracing of Excavations

THE attitude of the Milwaukee newspaper, commented upon elsewhere on this page, is in striking contrast with the attitude of the press of Chicago with reference to the cave-in of Randolph Street. The descriptions of the incident ran into many columns and some early opinions were expressed as to the cause. Little or no notice has been taken, however, of the careful report prepared by the municipal engineers after extensive investigations. This report —which was abstracted in this journal last week—indicates a definite line of action and design, which contractors and engineers confronted with similar problems may well study with profit, even if they do not agree with all the assumptions and details. A similar accident occurred at another tall structure in Chicago not so long ago, where it is said that the earth pressure transmitted horizontally to the base of a steel column of the building sheared off four 1-in. holding-down bolts and pushed the column within an inch of the edge of the footing casting before the accident was discovered and proper bracing placed. The commissioner of public works has now asked the building commissioner not to issue permits until the department satisfies itself of the sufficiency of the bracing for excavations. Engineers, public opinion and the newspapers ought to back him up, for, like the Milwaukee case, it is never too soon to pay attention to the small things which may easily develop into catastrophes.

Analytical Table of Contents

WITH the first issue of 1913 the Engineering Record began the practice of using its front cover in order to assist its readers in locating the specially important articles in the issue. The practice met with instant approval and numerous favorable comments have been received during the year. As the year wore on, however, it was felt that even this means, valuable as it was, did not go far enough. A portion only of the articles could be indexed, and this necessarily forced the subordination of many contributions, which, while of secondary importance, were nevertheless deserving of strong presentation. For that reason, beginning with this issue, page 3 of the advertising section will be used for an analytical table of contents. The space available will allow of adequate presentation of each title and of a brief summary of the article. The addition of the name of the journal and the date of issue makes the page convenient for clipping and pasting on index cards. In arranging the page so as to serve this dual purpose it is believed that both ends have been well accomplished. The use of a black-faced type for the title renders it quite as easy to pick out an article as if the explanation in smaller type had been omitted. The transfer of the index to this page does not mean, moreover, the abandonment of the use of the front cover for the benefit of the reader. On the contrary, it will allow of still greater flexibility in its use. While heretofore the presentation of the titles of leading articles was the only object in the use of the cover, it can be used in future in any way that will assist the reader in getting the most out of the journal and in promoting more intimate contact between reader and editor.

New York's Building Code

ONCE more a New York building-code draft has suffered disaster and is in danger of going the way of two preceding drafts—being thrown away after thousands of dollars had been spent on the revision. The previous drafts met a deserved fate, but the latest draft—to which this journal objected because of the principle on which it was based—was so much better than former efforts that disinterested students of the subject hoped it would be adopted. It was far from ideal, but was considered the best that could be obtained with the present views of the aldermen and their advisers as to code making. The latest draft was recently sent back to the revision committee and since the board went out of office with the close of the year, there is likelihood that the slumbers of the measure on the committee's shelves may not be disturbed.

The lot of these various drafts should convince the aldermen that the "specification code" is a thing of the past. As long as an omniscient document is aimed at, so long will drafts court the fate that has befallen those proposed at New York. The absurdity of trying to settle all details of construction and laying down rules which shall govern materials and equipment still in the womb of progress has been pointed out in these columns and has been ably presented to revision committees. What is needed is a simple code prescribing fundamentals only and vesting power in the superintendent of buildings to make detailed rules and to pass on new material and equipment. Some features of New York's building work are now so handled—and with success. The code covers these features only in a general way, and the superintendent from time to time makes regulations dependent upon progress in the art or the change in local conditions. Notice of a proposed new rule is given in ample season in the "City Record" and hearings are held at which protests may be entered; thereafter the rule is promulgated, and modified if necessary in the light of information brought out at the hearings. Appeal from the ruling may be taken, but as a matter of fact this right has never been invoked.

It is time that a code be written which is based on an amplification of this method of administration.

Columns and the Column Theory

ONE of the most complex engineering problems, and one which has vexed scientific men for centuries, is the determination of the stress distribution in solid bodies when such bodies are subjected to the action of external forces.

Galileo, in 1638, attempted to write an expression for the relation between the external and internal forces acting on and in a beam, but his result was seriously in error. Hook, in 1678, announced his law, and from his time down to the present there has been continual but slow advancement. In Mariotte's work entitled "Le Mouvement des Eaux," published after his death in 1717, he gives an expression for the moment of the normal forces on a vertical section of a beam—in other words, the resisting moment of the section. Mariotte's expression is not correct, but it opened the way and suggested to other investigators that such an expression might be correctly written. Jacob Bernoulli, in 1694, gave us the equation of the elastic line. Euler, in 1744, with the work of Bernoulli as a basis, developed his celebrated column formula, and later Lagrange and Navier elaborated Euler's work. In more recent times Rankine and Gordon have derived other column formulæ, which, due to the nature of the assumptions made in their derivation, have very little theoretical value.

In the engineering periodicals of the present time hardly a year passes without some contribution to the theory of flexure and, particularly, to the column theory. The writings of Fidler, Cain, Marston, J. B. Johnson, Moncrieff, Prichard and others have been of great value in developing the column theory to its present state.

The article by Mr. R. J. Roark which appeared in the last issue of this journal is a valuable contribution to column literature, even though the assumptions are not complete and all of the factors not taken into account.

As the author recognizes clearly in his article, it is probably far from true that the elementary cantilevers are fixed in direction along the line of their attachment to the web. The larger and thicker the web is the greater would be the degree of the fixedness.

The assumption that the elementary columns are long, which is the same thing as assuming that the direct load stresses are so small as compared with those due to the column flexure as to make them negligible, is for the practical column considerably in error. The effect of a moment in deflecting the axis of a column acting as a whole, and the related fact that the resulting flexural stresses are not equal in amount at all points equally distant from a given axis, have also been neglected in the derivation of the formula.

It appears, therefore, that the coefficient 23 in Mr. Roark's equation, $b = 23t$, should be reduced materially. The specifications of the American Railway Engineering Association require that "flanges of girders and built-up members without cover plates shall have a minimum thickness of one-twelfth of the width of the outstanding leg." This requirement reduced to an algebraic relation to correspond to that of Mr. Roark would be $b \underset{<}{=} 12t$.

Wooden Docks at San Francisco

GREAT activity is being displayed just now on the San Francisco waterfront, where many new docks are being constructed, to provide for the expected increase in commerce consequent on the opening of the Panama Canal. An unusually active interest has been evinced by the public as well as by the engineering profession. It is not surprising, therefore, that when the State harbor officials proposed to substitute wooden wharves for some of the concrete piers originally intended a violent storm of protest swept toward the Embarcadero, with the Ferry Building, the headquarters of the Harbor Commission, as a focus. To protect themselves from the tempest the commission hastily fabricated a structure of explanations and excuses.

That with timber a bigger showing could be made for the same money, that the bearing power of the mud was insufficient to sustain the weight of concrete docks, that the disintegrating action of salt water on concrete might eventually cause masonry piers to collapse, that greater speed in construction could be attained with timber—these were the wind braces, over which the commissioners spread a sheeting of geniality and complacence in the hope of furnishing for themselves a suitable shelter.

A bigger showing for the same money can be made with timber than with concrete, if first cost alone is considered, but when maintenance and life are weighed timber fails wofully in the comparison. The average life of creosoted piles in San Francisco Harbor is from 12 to 15 years. After that period has elapsed reconstruction is necessary. This is illustrated by the brief account in the Current News Section of this journal on Nov. 22, 1913, of the failure of a timber dock in San Francisco Harbor. The bonds for the contemplated pier construction mature in 74 years. There is a fund for the maintenance of harbor improvements, but not for reconstruction. For the $900,000 bond issue under which the proposed wooden piers would be constructed no sinking fund will be begun until July 2, 1929, about which time entire reconstruction would be necessary. Before 74 years shall have elapsed wooden piers must be reconstructed five times, with no funds legally available for that purpose.

It is unreasonable to maintain that the bearing capacity of the mud at certain locations along the Embarcadero is insufficient to sustain concrete piers. Clusters of concrete or wooden piles, surmounted below the mud level by concrete pedestals of sufficient area, are capable of sustaining the concrete piers originally proposed without the least danger of settlement. If the precedent of the Ferry Building, erected before the earthquake of 1906 on such concrete pedestals is insufficient, a simple and inexpensive test would convince the most skeptical.

While there are those who doubt the permanence of concrete in sea water, that feeling has undoubtedly come from observation of work exposed to salt water before being fully set up. There is no reason yet to believe that dense concrete properly cured before immersion is not permanent, particularly under the favorable climatic conditions at San Francisco.

Finally, although without doubt the Panama Canal will have a very beneficial effect on the maritime commerce of San Francisco, it is not anticipated that the day or month of its opening will see an armada of merchant vessels pass through the locks, bound for San Francisco. The increase in trade will probably be rapid, but there is ample time in which to provide concrete docks for the ships that will come.

Broader Relations of Engineering in 1913

THE technical advances during the year just passed are briefly summarized elsewhere in this issue. Matters of legislation and public policy have been touched on insofar as they apply to the particular branches of civil engineering discussed. Simultaneously, however, there have risen matters of a more general character, not applying to any specialty, and these it is proposed to discuss briefly here, in order that the review of the year may be complete.

Nationally two great engineering problems were to the fore—highways and hydraulics, the latter occurring in many aspects. Of "good roads" enthusiasm there was, and is, no lack. It has not been mere idle enthusiasm either, for the States have gone forward at a goodly pace in establishing highway commissions, perfecting their highway organizations, laying out comprehensive road systems and actually finishing, either through State funds, or jointly with the counties, a large mileage of improved roads. The enthusiasm, too, has strengthened the demand for both National roads and Federal aid, and at least the usual shower of good roads bills is expected in Congress as a consequence. The National roads propaganda, fortunately, is meeting with deserved opposition from those who see in it but an extension of the pork-barrel legislation which has made the public buildings and the rivers and harbors bills sinister jokes throughout the country. It is evident, however, that the cry for contributions from the Federal treasury will not be stilled, and, therefore, even those who, like this journal, believe that highway work is going along satisfactorily by State aid, are willing to support a sane and moderate Federal aid measure. To fight all assistance is to attempt to stem an avalanche. The wise policy is to guide the movement into right channels.

As above mentioned, hydraulic problems have received much attention during the year. The first of these to come forward, in point of time, was flood control, occasioned by the disaster in the Ohio valley during March. The result has been the active study of flood prevention measures throughout the valley—and to a smaller extent in other sections of the country—and the introduction in Congress of a number of flood-prevention measures. One of these, introduced at the instance of the National Drainage Congress, provides for the creation of a "Drainage Fund" to be used for the construction of flood-prevention works. The agitation, too, has directed attention again to the Newlands bill, which is a broad conservation measure, originally introduced in 1911, applying to water resources of every kind and for whatever use, and also to forest protection. It would create a Board of River Regulation, of nine men, having at its disposal a fund of $50,000,000 annually for 10 years to be used in protecting watersheds from denudation and erosion, in regulating the flow of navigable streams, in flood-prevention works and, in general, in "doing all things necessary to provide for any and all beneficial uses of water." There is reason to believe that as soon as the President clears away his set program of legislation, active efforts will be made to secure the passage, if not of one of these bills, then of some less ambitious measure, which will provide means for, at least, a comprehensive study of flood-prevention, so far as it is a National and not a local problem.

Hydroelectric development was also prominent nationally. Most important was the decision of the U. S. Supreme Court that water power in navigable streams vests absolutely in the National Government, as against all riparian owners. The permits granted by the new administration for developments on the National domain show a continuation of the policy inaugurated by former Secretary Fisher. In granting the Pend d'Oreille permit Secretary Lane embodied all the safeguards to the private interests seeking the permit that the law allowed, at the same time protecting the basic rights of the Government. The law, however, is so objectionable in its insistence upon permits revocable at any time at the discretion of the granting officer that no extensive development can be expected until the law is amended or repealed. The action of the National Conservation Congress in setting forth the requirements of sane water power legislation should be of great value in securing from the Federal Congress the needed statutory revision.

Of the great public works not treated of separately in the reviews to which reference has been made, the Panama Canal has progressed to the point where the sending through of large ships, experimentally, may be expected any day. Small service vessels have already made the passage from ocean to ocean. The opening of the canal to commercial vessels is, therefore, assured well before the promised date—Jan. 1, 1915. The New York State Barge Canal is rapidly nearing completion.

Turning from specific problems, one of the most encouraging signs of the year is the more frequent participation of engineers in public affairs—not merely as individuals but through their organizations. The local societies deserve much credit for this work. The American Institute of Electrical Engineers rendered good service in advising a congressional committee which was considering water-power measures. Within the past few months the American Institute of Consulting Engineers addressed the President of the United States, the Governor of New York and the Mayor-elect of New York City with reference to the appointment of engineers to offices largely concerned with engineering matters. Good starts have been made, but these cases are few compared with the opportunities. The American Society of Civil Engineers with its ample means and able membership is in a position to do good work, and seems about to break away from its ultra-conservative position. Indications of the opportunities open to it are afforded by its recent appointment of committees to draft a national water law and to report on methods of evaluating public utilities.

The internal activities of the national societies have been notable. The American Society of Mechanical Engineers met in Europe in company with the Verein Deutscher Ingenieure. It continued during the year its marked expansion in activities, both in the establishment of branches and in the amplification and vigor of its committee work. The American Institute of Electrical Engineers has likewise shown a continuance of its remarkable activity, though it passed through the throes of a controversy in readjusting its membership grades—a readjustment that was unfortunate from the standpoint of the profession at large, in that the grade of "member" in the national engineering societies is now even less comparable than before.

The American Society of Civil Engineers has made notable progress in the establishment of branches, and started a custom, which was most favorably received, of holding a general meeting, other than the annual convention, outside New York City. Signs of dissatisfaction with the policy of the society have been noted, and, at the same time, a disposition on the part of the officers to make the society of greater service to its members. The conditions which need remedying were very frankly discussed by Professor Swain in his masterly presidential address at Ottawa. If the suggestions he advanced are taken hold of vigorously, there is no doubt that the complaints will disappear.

One of Professor Swain's strong pleas was for a larger participation of the engineer in public affairs. The signs are promising and the times propitious. There is no doubt that the National problems above referred to will arise again this year in forms requiring more than ever vigorous handling and clear appreciation of the engineering factors involved. The matter is one not only for the individuals but for the officers of engineering societies. If the latter take the initiative they will not lack the assistance of willing workers.

Review of the Year

Summary by Eminent Specialists of the Engineering Developments
during 1913, with Forecasts of the Progress in the Immediate Future

CONTRIBUTORS

GEORGE G. ANDERSON
HENRY M. BYLLESBY
L. C. FRITCH
GEORGE W. FULLER
SAMUEL A. GREELEY
ALLEN HAZEN
CLEMENS HERSCHEL
HENRY W. HODGE
W. A. ROGERS
FRANK W. SKINNER
COL. W. D. SOHIER
SANFORD E. THOMPSON

Financing of Public-Utility Enterprises

Present Curtailment Not without Benefit to Corporations, though Detrimental to Communities Affected; Outlook Has in It More of Hope Than Discouragement

By HENRY M. BYLLESBY

President, H. M. Byllesby & Company, Chicago

DURING 1913 requirements for capital in all lines of industry have exceeded the available supply. The conditions compelled public utilities to curtail construction improvements and extensions. This pause, while beneficial to most utility corporations, has been detrimental to the communities affected. It has given many companies an opportunity to perfect operating economies and to realize on accessions in business brought about by previous construction and commercial activities.

To serve the public adequately, however, large capital expenditures must be made within a comparatively short time. Otherwise, community growth and progress will be checked. Corporations, together with private citizens, are laboring under greatly increased tax burdens, and these added imposts are quite general throughout the country. A large proportion of the tax increase is for the purpose of paying interest upon public debt created for all kinds of governmental activities, not a few of which are of doubtful value. The financial obligations already assumed cannot be repudiated, but many citizens are counselling immediate discontinuance of reckless and unnecessary municipal borrowing.

Public-utility securities are widely distributed among the public. Gross earnings of the majority of these corporations have continued to increase steadily, despite the money stringency and business recession, by repressing highly speculative utility undertakings and preventing competition in essential monopolies where the field is already being well served. Regulation by State commissions is proving beneficial to investors in progressively conducted service corporations. The commissions are evidently trying to be fair. As each new commission becomes familiar with its work the tendency is to accord the utility companies every reasonable opportunity to be both efficient and prosperous. There are no problems in the present-day status of utility corporations which cannot be solved by the application of common sense and patience when the representatives of both the public and the corporations are animated by a sense of justice.

The United States is a long way from the adoption of the socialistic doctrine of despair. The forthcoming year promises to be one of financial, industrial and sociological reconciliations; the outlook has in it much more of hope than of discouragement. Before the close of the coming twelve months, therefore, it is not unreasonable to anticipate the resumption of a substantial flow of capital into the productive and constructive enterprises upon which the welfare of the nation and its people depends.

Progress in Water Supply

Important Developments in Large Cities; Purification Becoming Well-nigh Universal in Principal Centers; Status of Disinfection; Opportunities for Joint Supplies

By ALLEN HAZEN

Of Hazen & Whipple, Consulting Engineers, New York City

FIRST in importance among water-supply events during 1913 may be mentioned the completion of the new Los Angeles supply. This was a monumental undertaking, conceived with the greatest boldness and carried out with vigor. It furnishes an abundant supply of superior water to a great and rapidly growing city in a region where local sources, never great, had been so far taken up that a further draft on them could not be made without injustice to other users.

The construction of this work has served as an object lesson in what can be done by cities in the construction of public works by the day-labor system where able men are employed to superintend the work and are given the fullest authority to manage it in a businesslike manner. The works also serve as a conspicuous example of the savings that can be made in design where frost is not present to undermine and destroy the completed work, and of the savings in construction in a climate where practically every day in the year may be a working day.

Hetch-Hetchy Supply

Two of the three great Pacific Coast cities—Los Angeles and Seattle—are now supplied with mountain water. The third—San Francisco—has long desired a mountain supply, and took steps to acquire the lands and water rights for its development. In this effort it has met many difficulties.

The consideration of and final enactment of the Raker bill, granting the city such additional land in the Yosemite National Park as is needed to carry out the proposed Hetch-Hetchy work, has attracted much attention. The bill was opposed vigorously because it might tend to reduce the value of the waterworks plant owned by the Spring Valley Water Company, now supplying the city; because it took water that it was supposed might otherwise be used for irrigation; and especially because it gave to the city a very small part of the land in the Yosemite National Park.

The first of these objections was removed by the arrangement that the new supply was not to be used until the company's plant had been bought at a fair price. The second, by the fact that the water to be used by the city is flood water now going to waste that will be saved and made available by the Hetch-Hetchy reservoir, and that saving it would not diminish the amount of water available for irrigation; and by the further fact that all irrigation rights are protected by the State law, and nothing which the city could do, or which the Government might permit the city to do, would diminish any existing right.

The third point, relating to the invasion of the Yosemite National Park, was pushed most vigorously by newspapers, clubs and societies throughout the country. The opposition was pressed, regardless of the fact that the city had long since acquired title to the floor of the Hetch-Hetchy valley for the purpose of water supply, and that the city's lands, although within the park boundaries, were not park lands, because the act of extending the park limits does not take away or make a park of private property.

If half of what the best newspapers of the country alleged to be facts had been true, the bill could never have passed. As against the idea that the park would be damaged by the proposed works the view is strongly held by many of those best informed that the reservoir will add to the beauty of the park, as the roads necessary for its construction will add to its accessibility and usefulness.

DENVER SITUATION

A decision of the United States Supreme Court, reversing a decision of a lower court, held the franchise of the Denver Union Water Company to be invalid. Several Western States have laws that deal equitably with situations of this kind, but Colorado has no such law. In the absence of such provision a delicate condition is created. It is to be sincerely hoped that an arrangement will be made between the city and the water company which will prevent the sacrifice of the company's plant and the construction of a duplicate and unnecessary plant by the city. Such a sacrifice of natural resources and of invested capital would not be permitted under the wise laws of many States.

The year has been marked by an increasing study of the question of fair rates for privately owned water companies, and, on the whole, the trend seems to be rather to regulate existing water companies than for the municipalities to acquire them.

WATER PURIFICATION

The progress of water purification during the year has been considerable. Two great cities have adopted filtration and are now installing plants. One of these—St. Louis—adopted ten years ago a partial method of water purification, which marked a great improvement on previously existing conditions. Perhaps the example of other cities with more complete plants, maintaining supplies of superior quality, has served to bring about dissatisfaction with the partial purification and has led to the adoption of the more complete treatment.

Cleveland, after persistent efforts, extending through many years, to secure pure water by driving tunnels farther out under the lake and by carrying sewage to distant points of discharge has wisely reached the conclusion that the filtration of the water is both a more certain and more economical method of reaching the desired result.

The defeat of a project for filtering Croton water supplied in New York City is to be recorded. The plans had been carefully prepared by competent engineers, the work had been authorized and bids received, when pressure was brought to prevent the award of a contract to any bidder. It must be considered that this most important work is only temporarily postponed, for New York City will not much longer consent to be supplied with water inferior in quality to that of neighboring cities.

With filter works for Baltimore in progress, the circle is rapidly closing, and the time is not far distant when every large American city will supply to its people water of excellent quality, the quality being secured either by means of artificial purification or by other adequate safeguards.

The year has been an important one in the development of the art of disinfection. It has become more and more clear that the proper field for this process is as an auxiliary to filtration. The use of hypochlorite of lime, which became common a few years ago, has been gradually and greatly extended, and the advantages of its use have become so apparent that disinfection either in its present or some equivalent form will always be insisted upon. On the other hand, continued experience has shown the difficulty, or perhaps sometimes the impossibility, of disinfecting waters adequately with hypochlorite of lime without at the same time producing disagreeable tastes and odors. The use of liquid chlorine as a substitute is being extended, while ozone and the ultra-violet-ray methods are receiving increased attention as offering promise of being able, with improved apparatus, to furnish the desired disinfection without the production of disagreeable tastes and odors.

CO-OPERATION BETWEEN CITIES

An encouraging spirit of co-operation between cities has during the year been manifested in several cases. The joining of Oakland and all the bay cities with San Francisco in the effort to get the Hetch-Hetchy water supply may be first recorded. Salem and Beverly, Mass., taking their supply from the same source, have, after years of contention, agreed to build by joint action the added works needed for the development of the source; and there is a prospect of a similar happy agreement between Norfolk and Portsmouth, Va. In both cases combination means large savings in first cost and operating expenses, and, in consequence, also in the water rates.

Such co-operation, if obtainable, would clear up other troublesome water-supply problems. In the southern part of Westchester County, immediately north of New York City, a scattered urban and suburban population has frequently suffered from a shortage of water that would justify a new and more adequate supply. From a physical standpoint works could be easily secured within limits of cost that would not be burdensome, but the difficulty or impossibility of securing co-operation between the various municipalities and water companies blocks a solution that would otherwise be advantageous.

Finally, the year 1913 has been marked by the reorganization of the American Waterworks Association, with provision for the formation of local sections in various parts of the country. This gives promise of new life to the organization and greater helpfulness to waterworks men.

Advances in Sewage Disposal

Activities of United States Government Especially Notable; Substantial Progress in the Development of Experiences of Earlier Years

By GEORGE W. FULLER
Consulting Engineer, New York City

THE year 1913 saw no extraordinary achievements in the field of sewage disposal, but substantial progress was made, mainly in the development of the experiences of earlier years.

ACTIVITIES OF THE GOVERNMENT

Most notable is the activity of the United States Government through the Public Health Service in investigating the effect of the present pollution of interstate streams, the extent and efficiency of natural purifying agencies, and the relation of existing conditions to the public health. This work comprises an investigation of the Potomac and Ohio rivers and special studies of the fundamental principles of self-purification. Studies are being directed along lines somewhat different from those previously followed and are being made in the light of the modern views of the biochemical reactions occurring during the oxidation of organic matter.

This work is of interest because for the first time in about thirty years since the work of the National Board of Health was begun the Federal Government is taking cognizance of matters related to this branch of the sanitarian. Up to the present time the Federal Government has exercised no control over sewage disposal except as sewage deposits affected the shoaling of navigable waters. The Government apparently intends now to secure data on the effect of stream pollution on the public health as a preliminary to possible future legislation.

Among practical accomplishments the most important is the demonstration at the Proctor Creek plant at Atlanta that the two-story tank of the Imhoff type affords as satisfactory a means of preliminary sewage clarification and of inoffensive sludge disposal for American conditions as had been indicated by its use in the Emscher District in Germany. Besides satisfactory sludge handling in two-story tanks, it has been demonstrated by Dr. Imhoff and his staff that with single-story tanks it is feasible under suitable conditions to transfer, regularly and at short intervals, fresh sludge from the sedimentation tank to a separate sludge-digesting tank, and there secure proper and inoffensive sludge digestion. Sludge disposal in compartments where there is not a thorough mixing of the fresh with the septicized sludge, as attempted in the covered sludge trenches at Kings Park, N. Y., is not a success.

SLUDGE

At Toronto plain sedimentation tanks, rectangular in form, with hopper-shaped bottoms, have not proved altogether successful, as the sludge is removed with difficulty and objectionable odors have attended the drying of the sludge on the adjoining lake shore. The Schaefer-ter-Meer centrifugal drier for fresh sludge has been adopted in the Bronx Valley Sewerage Commission's project.

In treating the flow of combined sewers, grit and detritus from street washings have been troublesome because of the inadequate capacity of grit chambers and unsatisfactory means for cleaning them. Better designs will provide either small grit chambers with continuously operated grit-removal appliances, as at Columbus, or a flexible series of grit chambers to be used at times of storm and of sufficient capacity to retain volumes of grit far in excess of those usually provided.

ODORS—DISINFECTION

Bad odors attending sewage-treatment works are indicated by experiences at Columbus and at Baltimore to be largely due to depositing velocities in the sewers. Besides liberal and frequent flushings, hypochlorite of lime, as used at Baltimore, is of assistance in reducing odors, and the effect of the aëration of the sewage at points in the intercepting and outfall sewers is being studied with care. It is now appreciated more clearly that the absence of offensive odors, as at Reading, Pa., is explained in part by the constant presence of oxygen as the sewage flows to and through the sprinkling filters and in part by the general scouring velocities in the collecting system.

Hypochlorite of lime has been systematically used at the treatment works at Providence and Toronto, as well as at some smaller plants. Liquid chlorine has come up for consideration and has formed a part of the equipment for several projects recently placed under contract. Automatic devices for the control of the application of the liquid chlorine at predetermined rates through the use of the apparatus of the Electro Bleaching Gas Company or the Leavitt-Jackson Engineering Company are noteworthy. It is claimed that the liquid chlorine acts more quickly than does hypochlorite of lime and that there is a substantial saving of liquid chlorine as compared with the so-called available chlorine in hypochlorite of lime. So far as known the facts as to this relationship are not definitely established.

SPRINKLING FILTERS

Sprinkling filters have to their credit one more victory in that they now give promise of supplanting intermittent sand filters even in New England, where the glacial drift formations of porous sand form natural sand filters at less expense than is usual in America. Such sprinkling filters have recently gone into operation at Brockton, Mass., and will be used at the new works under contract at Fitchburg, Mass. Ten acres of sprinkling filters at Columbus, under the local conditions as to depth of bed, preliminary treatment and method of application of influent, are not capable of giving a non-putrescible effluent for a population of about 180,000. Extensions to the filters and modifications of preliminary treatment will soon be required. At Reading filters receiving after sedimentation the flow from separate sanitary sewers are successfully carrying a load of about 18,000 people per acre on beds having a depth of about 6 ft. of stone or 5 ft. of slag.

At the Lawrence Experiment Station some interesting tests have been made of aëration as a means of increasing materially the rates of filtration. To what extent this is commercially practicable is not now known. The city of Worcester has published the results of its tests in the use of two-story tanks and sprinkling filters for local conditions. Tests have also been made on various aspects of sewage-disposal problems at Chicago, Philadelphia, Akron, Cleveland, Brooklyn, Staten Island, Toronto, etc.

STATUS AT NEW YORK

Within the metropolitan district of New York City construction has proceeded for the discharge of the sewage of the Passaic valley into upper New York bay. The Metropolitan Sewerage Commission of New York City has issued preliminary reports proposing an outlet island about 3 miles south of Coney Island to which to divert a substantial part of the sewage flow now draining into the East River. This suggestion has not made a favorable impression on the engineering profession, both because the expense required will not give results of commensurate value and because a wrong conception by the commission of the necessary minimum quantity of dissolved oxygen in the river water has led to an erroneous conclusion as to the amount of improvement needed.

FUTURE DEVELOPMENTS

Immediate future developments can be expected on the following lines:

1. Better designs for grit chambers.
2. A further use of two-story Imhoff tanks with steeper slopes for the upper and lower compartments.
3. The adaptation of single-story sludge-digestion tanks to be used in connection with existing settling tanks.
4. Increased attention to the effect of sewage-collecting systems on the non-odorous and efficient treatment of sewage.
5. A correction of the extravagant views at present held by some sanitarians of the minimum quantity of dissolved oxygen needed in diluting waters, and an adaptation of disposal projects to the corrected basis.

Future of Steel Construction—A Prospect

Probable Development of High Buildings and Long-Span Bridges; Remarkable Increase in Production; Opportunities Presented by Export Market

BY HENRY W. HODGE

Of Boller, Hodge & Baird, Consulting Engineers, New York City

THE scientific use of iron or steel for construction purposes is so comparatively modern that no great retrospect is possible. The first wrought-iron bridges were built in England by George Stephenson in 1824. Steel building construction, in the modern sense, was first developed in the late '80s though of course iron floor joists supported on masonry and cast-iron interior columns had been used for a long time prior to that date.

RAPID ADVANCES IN STEEL BUILDINGS

Building construction has probably made the greatest advance, as in twenty-five years we have jumped from the eleven and fourteen-story buildings of the '80s to the fifty-seven-story 750-ft. Woolworth Building, and in large centers of population, where the cost of land is high, the "steel-frame" building has entirely displaced the old type of masonry construction.

In bridge construction the advance has not been so rapid, but nevertheless it has made great strides, and the ingenuity of the manufacturers and shippers has been taxed to keep pace with the great and continuous increases in size of members demanded by the bridge structures now in general use.

This advance in design and size of construction has also called for great improvement in the quality of materials. We quickly went from iron to steel, and now we are fast going from steel to its alloys—nickel, vanadium, and other metals, which have been found to increase its strength in greater proportion than its cost.

If, then, we have made such great advances in steel construction in the last few years, what are the prospects for the future? Have we reached the zenith of such construction, or are there still other possibilities of advancement? I am convinced that the use of steel and its alloys in construction will make greater advances in the future than it has made in the past, both for bridges and buildings.

The 1000-ft. Eiffel Tower, in Paris, is convincing proof that buildings of a hundred stories are not only possible but probable, as our great cities are continually becoming more densely populated, and land values are in some cases exceedingly high. Very tall buildings are seriously objected to on account of the obstruction to light and air, their appearance, the congestion they cause in narrow streets, the possible danger from fire and panic, and for other reasons, and their height is being limited by ordinances.

There is certainly no engineering obstacle to the construction of buildings of more than the present maximum height, and while the incident problems, such as elevator service, etc., are serious factors to be contended with, yet they undoubtedly can and will be solved, as the demand requires. The greatest drawback to the construction of buildings of such heights is the insufficiency of the streets of a city, as now laid out, to accommodate the population that such buildings would accommodate, and this capacity of the streets will, in my opinion, set the final limit on the heights of adjacent buildings.

To construct buildings of, say, twice their present maximum height would put no increased tax on the manufacturer or shipper, as our present materials are of ample strength, our shops are fully equipped to manufacture the necessary parts, and our railways can readily carry them.

BRIDGE CONSTRUCTION

In bridge construction there is also a field for advancement, even beyond the great spans now in existence. With the new materials now coming into commercial use we can greatly increase the strength of members without corresponding increase in weight; and the fixed weight of long spans is the greatest obstacle to increase in length. Furthermore, with very long spans the matter of impact becomes practically of no effect, owing to the fact that a relatively small portion of the entire load is a moving load, so that higher unit strains can be used, and types that are subject to considerable vibration and deflection in short spans can be used with safety and efficiency in very long spans. For example, the suspension type of structure will enable us to build spans largely exceeding those now existing, and this type will not require any great increase in the present size of individual members.

There is, in my opinion, a great field for advancement and development in this branch of engineering, and the engineer of the future will probably look on our present construction as we do on that of fifty years ago.

NEED OF A NEW MATERIAL

What is most needed for the development of structural undertakings of great magnitude is a material which will have a greater strength, without sacrificing its ductility or increasing its cost to the extent of its increase in strength.

The engineers in this field of investigation are giving constant thought to this object, and the successful results they have already obtained with various alloys and special treatments lead us to believe that they will develop still more efficient materials.

While, however, the progress toward greater structures and bridges is sure, it will not be in such structures that the greatest tonnage will be used, but in the so-called "small commercial uses" to which this material is put. That the quantities so employed are not as small as those used in structures and bridges will be a surprise to many. The following figures from statistics of production in the United States in 1912 will give a very good idea of the relative amounts of steel employed for various purposes, the tonnages being given in round numbers:

Rails, 3,300,000; structural shapes, 2,800,000; wire rods, 2,700,000; plates and sheets, 5,900,000; merchant bars, 3,700,000; total of all finished rolled forms in 1892, 6,200,000 tons; in 1902, 13,900,000 tons; in 1912, 24,700,000 tons.

It will thus be seen that the structural shapes, which, with a portion of plates, constitute the material in structures, are a very small portion of the total steel used.

It will be further seen that we are doubling our total production every ten years. Our engineers and manufacturers have recently awakened to the great foreign market which has heretofore been practically monopolized by Europeans, and we are now designing a large portion of the bridges and structures of other countries, especially of South America. This is evidenced by our export in 1912 of manufactures of iron and steel to the value of $289,000,000, as against imports of the same materials of $29,000,000. Of this total of $289,000,000 of exports $120,000,000 was in various classes of machinery and only $13,000,000 in structural steel. Our total exports of manufactures of iron and steel are being tripled every ten years, as shown by the following figures: Value of exports, 1892, $27,900,000; 1902, $97,900,000; 1912, $289,100,000. We are now exporting ten times as much as we import, and this field has only commenced to develop, so that we need have no fear for the continued development of the steel industry in the future.

Structural-Steel Work in 1913

Year Marked by Competition and Inception of Noteworthy Bridges and Buildings, Important Renewals and the Broadening in Variety of Uses

By FRANK W. SKINNER
Associate Editor, Engineering Record

THE value of steel structures fabricated and erected in the United States annually is rapidly increasing and is estimated at more than $400,000,000 in 1912, and was probably 10 per cent greater during 1913. Obviously since bridges and steel buildings have already attained such enormous tonnage, great variety and large dimensions, their design and construction must now be so well developed that radical changes, sudden advances, notable increase in the magnitude or great variations in the standard types are not to be expected. The advance in steel construction should be steady and conservative, perfecting and modifying present practice. A review of the past twelve months' record discloses steady progress in design, fabrication and construction.

BRIDGES

Work is under way on the 1800-ft. span (the largest yet commenced) of the $9,000,000 superstructure of the Quebec Bridge. Its design has involved an unprecedented amount of research and collaboration of eminent engineers, resulting in the adoption of important special features of fabrication and erection.

The Memphis Bridge, with three main spans aggregating 2015½ ft. in length, and including a 790½-ft. cantilever span, is now under construction. It ranks high among the very long and heavily loaded bridges, and will be notable for the important decrease of dead load and increase of strength due to the use of alloy steel for some of the principal members.

The record of length for bascule spans has been broken by the completion of the 235-ft. double-track leaf of the lift bridge for the Baltimore & Ohio Railroad across the Calumet River at Chicago. This bridge, with a counterweight supported on levers, is an example of a recently perfected system with direct counterbalancing, mechanically controlled to correspond automatically to the moments of the bascule leaf. A different type of movable bridge span with direct-lift counterbalanced spans has also been developed.

One of the most important bridge renewals of the year has been that of the Lachine Bridge—3657 ft. long—across the St. Lawrence River. It was built in 1886 as a single-track structure. The old superstructure has just been replaced by new double-track spans, erected without interruption of traffic or navigation. A significant feature of the work was the construction of a number of intermediate piers, reducing the length of several spans by one-half, a tendency which may be observed in a number of recent renewals.

Some difficult and unusual erection work of magnitude has been successfully accomplished, including the building of the Ohio River Bridge at Kenova. The structure has five 518-ft. river spans about 100 ft. above the water. The new trusses were assembled outside of the old ones while the latter were in service. They were erected as cantilevers and adjusted for final connection by vertical movement of the adjacent spans, which temporarily served as anchors.

The replacement of the three-span Portageville Bridge, about 482 ft. long, by a new superstructure erected alongside on falsework and moved transversely into position, displacing the old superstructure between trains, was an operation of unusual magnitude for this class of work. An aggregate weight of 2,500,000 lb. was safely moved 19½ ft. transversely in three minutes, the track connections being broken only about two and one-half hours. This illustrates a successful method employed with increasing frequency for replacing spans under heavy traffic.

PROPOSED BRIDGES

The most interesting large span to be built in the immediate future is the four-track 1000-ft. arch span of the Hell Gate Bridge across the East River at New York, which is now under contract.

Investigations have been made and preliminary designs and estimates prepared for an eight-track 3880-ft. suspended span across the North River at New York. It is to accommodate railroad, electric, and highway traffic, and its promoters believe that it is likely to be constructed, and can be built for about $42,000,000. A much lighter suspended highway span of 2700 ft. has been proposed in England, but definite information concerning it is lacking.

The completion of the fifty-seven-story Woolworth office building in New York establishes a new record for tall buildings. This $12,000,000 structure contains about 23,000 tons of structural steel, which is chiefly interesting on account of the very heavy double plate-girder portal construction in the wind bracing system and for the massive foundation girders transmitting column loads to eccentric pneumatic caisson piers. The thirty-five-story building, 465 ft. high, in Seattle signalizes the advance of extremely tall office buildings on the Pacific Coast.

The roof trusses for the Armory of the Eighth Artillery District National Guard in New York City have a span of 300 ft. and weigh 50 tons each, thus making them among the longest and heaviest roof spans ever built.

Several important steel buildings of notable magnitude have been proposed, of which the erection has not yet been commenced. Among these is the forty-story Equitable office building in New York, which will contain about 32,000 tons of structural steel and will cover an entire block, making it one of the largest of office buildings.

Preliminary designs and estimates have been made and considerable preparatory work has been done toward insuring the construction of the Pan-American Building in New York, which will probably be located near Columbus Circle and have a height of 800 ft.

The huge hollow-steel gates for the Panama Canal locks aggregate about 60,000 tons of riveted steel. A large amount of structural steel has also been used for aqueduct pipes, some of them designed to resist a pressure head of 850 ft. Tall steel towers, up to 600 ft. high, have been built for the wireless telegraph service of the United States Government. Quadruple steel tubes have also been successfully launched and sunk for the construction of a difficult tunnel to cross the Harlem River at New York City.

Design and Fabrication

Important contributions to the fundamentals of the design of great bridge structures have been made during the year by papers from Mr. Ralph Modjeski, of Chicago, and Mr. Joseph Mayer, of Montreal, treating of the methods of analyzing, estimating and proportioning great bridge spans, special reference having been made in them to the new Quebec Bridge.

Progress in the æsthetic treatment of structures has been made in the prominence given to the design of graceful outlines for important city bridges and for monumental construction, as well as by artistic treatment for concrete construction combined with or inclosing heavy girders and other steelwork.

The great volume of steel construction during the year was emphasized by the extraordinary congestion of the rolling mills, which was so great that during the early months detailed rolling schedules were fixed for more than half a year in advance. It was generally impossible to place moderate size orders for delivery until late in the season. Such an amount of business, combined with the ruling high prices, inevitably encouraged the extension and improvement of plants, and explains the investment of over $100,000,000 in new steel works.

During the year a fabricating plant of the highest grade and of unusual capacity has been installed and put in operation at the $1,000,000 bridge shop in Montreal, equipped primarily for the construction of the Quebec Bridge. This plant has been arranged with powerful imported and domestic machine tools, designed specifically to handle heavy and very heavy bridge members in separate classes, including the accurate machining of pieces up to 90 ft. long and of 140 tons in weight.

Field and Laboratory Investigations

Important research work has been done in accurate large-scale tests and experiments in the field and the laboratory. These include extensometer measurements of great range and precision to determine the dead and live load stresses in the Beaver Bridge under actual service and some important and elaborate tests on large-scale carbon and nickel-steel models of members in the new Quebec Bridge. The latter were tested not only for ultimate strength but also for efficiency of connections and of details of construction. They showed a remarkably high ratio of ultimate strength for the alloy steel used, and have justified more experimental work and the consideration of this material for still further application in important structures. Tests, the result of which have not yet been publicly disclosed, have also been in progress on the action of columns in tall office buildings under the application of dead and live loads,

A series of investigations commenced several years ago has also been continued and published, dealing with impact and the live-load stresses resulting from train loads at different velocities and weights passing over spans of different lengths.

A new aspect of steel construction has already forced itself into prominence in the renewal of important buildings. Some of the tall office buildings that were considered notable not more than twenty years ago have already been torn down to make place for very much taller ones on the same site, as, for example, the Tower Building in New York, which was erected in the late '80s, and the Trude Building in Chicago, of about the same height, and erected about the same time. It is satisfying to know that so far the condition of the iron and steel has generally been reported to be very good, with only minor indications of injury from electrolysis and corrosion. Wind stresses and traffic loads can be positively provided for. It seems, therefore, that a reasonable degree of care in protection from corrosion, especially in the substructure, will give all the necessary permanence to the steelwork of these buildings.

The absence during the year of serious structural disasters speaks well for the quality of design and of erection work, both of which are undoubtedly improving.

From the Standpoint of the Contractor

Year Generally Quiet throughout the Country; Labor Ample in Quantity but Poor in Quality; Probable Influence of Currency Bill and of Increase, if Granted, in Freight Rates

By W. A. ROGERS

President, Bates & Rogers Construction Company, Chicago

AT the beginning of 1913 prospects were good for a very busy year for contractors. Many had work on hand which had been awarded in 1912, and which was to be completed in 1913. In addition to these unfinished contracts there was apparently a large amount of new work in sight. The railroads were planning extensive improvements in the nature of grade revision, second tracking and construction of new main tracks and branch lines. Considerable municipal and Government work also was contemplated. Shortly after the first of the year conditions gradually changed; particularly, much of the new railroad work which had been expected failed to materialize. As a result 1913 has been characterized by the small amount of new railroad construction undertaken. Contractors, as a rule, have been only fairly busy, and the year may be said to have been "quiet."

In the East there has been the usual amount of work in and around New York in connection with the subway extensions and the Catskill Aqueduct. The new railroad development which had been projected for New England was stopped, although it has recently been resumed.

Throughout the Middle West there has been considerable activity in Indiana and Ohio, due to the necessity of repairing the damage caused by the disastrous spring floods. These necessitated extensive bridge work for municipalities and counties, as well as for the railroads.

Conditions in the Northwest and South

In the Northwest very little new railroad work was put under contract, in marked contrast to the conditions which obtained a few years ago. From 1906 to 1911 there was an immense amount of railroad building, followed by a large growth of communities and general development throughout the section. With the curtailment of construction there has been a slowing down of business, showing, in one way, the effect which the prosperity of the railroads has on the communities served.

In the South conditions were similar to those in other parts of the country. There has been only a small amount of railroad work under contract.

The work in connection with the improvement in the Ohio River by the Government has been favored during the latter part of the season with a fair working stage. During the spring the floods caused serious losses to the contractors.

In Canada little new work was undertaken. The great amount of work already started on the transcontinental lines, however, made good progress. Labor and weather conditions have been favorable.

As a rule, comparatively low prices prevailed during the year. In many cases they have been so close that the work necessarily must have been done without profit. A few years ago prices, particularly in the Northwest, were good. Conditions have changed, and now in the Northwest, as well as elsewhere in this country and Canada, the prices are very close.

LABOR SUPPLY

The labor supply throughout the United States and Canada during 1913 has, as a rule, been sufficient for the work in hand. An exception occurred during harvest, when there was a serious shortage, which was relieved as soon as the crops were in. While labor was ordinarily sufficient in quantity, the quality was not good.

The poor quality is not an entirely new difficulty. There has been a marked change in the class of laborers in the last ten years. English-speaking labor is now largely of the "short-stake" class. A man of this type, with the comparatively high wages prevailing during the last few years, is able to earn enough in a few days for a spree. He is constantly shifting. Moreover, the foreign labor is largely from the south of Europe. Laborers of this class are slow to learn. They cannot be directed in English, and are able to do only the most simple kind of manual labor. We have among our laborers now very few of the sturdy, ambitious north of Europe men, who were so plentiful a few years ago. Though the wages paid have increased, the efficiency per man has steadily decreased.

A feature emphasized in 1913 is that there seems to be an evening-up process in the rates paid for labor in the different parts of the country. From 1906 to 1911 there was a variation in the price paid for common labor of as much as $1 per day between the Atlantic and the Pacific Coast States. The difference now is not over half that amount. Conditions indicate that a much lower rate will prevail in the future, for there is an increasingly large number of idle men in Canada.

OUTLOOK FOR 1914

What is the outlook as to construction work for 1914? It may be reasonably assumed that there will be the usual amount of Government work and probably the usual amount of municipal work. The uncertain feature is the amount of railroad and private work in the United States and Canada. In Canada there will likely be less railroad work than there has been for some years. The large transcontinental projects are drawing to a close. Money also is comparatively tight in the Dominion.

In the United States there is a very general feeling that if a moderate increase of freight rates is permitted, thus indicating that the attitude toward the railroads has changed for the better, the amount represented by this moderate increase would be spent many times over in much-needed improvements. The opinion is general, too, that almost without exception the railroads of the country need to spend large sums on terminals, grade revision, and the construction of feeders, and that they are only awaiting the time when they can successfully finance these improvements. The writer feels that if the currency bill, just passed, has a beneficial effect on the finances of the country, and if the railroads are permitted to charge back to the public, in the shape of higher rates, a small portion of their increased expenses, we will have not only a busy construction year but a prosperous year for the country—for the prosperity of the country is, without question, dependent to a large extent on the prosperity of the railroads.

Status of Hydroelectric Design

Improvements during the Year Have Been in the Direction of Higher Wheel Efficiencies, Greater Simplicity in Details and Lower First Cost

By CLEMENS HERSCHEL,
Consulting Engineer, New York City

DURING the past year several large hydroelectric stations—notably those at Keokuk, Tallulah Falls, Ga.; Hale's Bar, Tenn., and White Salmon River, Ore.—have been put in operation. Many of them disclose new features not only in the wheels and wheel settings but also in the penstocks and auxiliary apparatus. Of the developments under way the most significant are those at Cedars Rapids, near Montreal, which will have an ultimate capacity of 160,000 hp, and a Swiss plant which will operate under a head of 5400 ft.

DAMS AND PENSTOCKS

Two large dams, intended to be the highest in the world, are under construction in the West. The gravity section still seems to be the favorite, although dams of several other types have been built. Interest has also been aroused in this country in the rolling type, promising developments in the design of combination dams. At Tallulah Falls automatic dam gates, having an overhead movable roller, have been installed, and another installation with direct counterweighted flashboards is under construction.

Wood-stave pipe still holds the field for long pipe lines, and during the year an installation 5070 ft. long and 13½ ft. in diameter was finished. For very high heads welded steel pipe is still the most acceptable, while for heads intermediate between those for which wood-stave and welded lines are used the riveted pipe serves satisfactorily. Seamless tubes have been used for penstocks less than 1 ft. in diameter. At the San Francisquito development a portion of a 7-ft. welded pipe, 1 3/16 in. in thickness, was banded.

No material change has taken place in gate arrangement, except that electrical operation seems to be forging to the front. This, however, for medium and high-head plants necessitates the use of reliable outside emergency power, as was forcibly shown in a recent accident in Utah. For low-head plants no novel gates have been built, but a siphonic intake, eliminating gates, has been proposed.

Modern hydraulic engineering has reduced the practical number of types of water-power prime movers to two—the Francis turbine and the impulse wheel—now adapted to cover the entire range of head from the present lowest commercial limit of from 6 to 7 ft. to heads exceeding 5000 ft.

There is no pronounced limit in the use of either type with reference to the head. Francis turbines can be used from lowest heads up to 1000 ft. or more, provided that the capacity under that head is sufficiently large to allow of reasonably big passages between guide vanes and runner vanes. Impulse wheels can be used under as low heads as may be desirable for special purposes, provided the power to be developed is reasonably small.

The fact that practice has limited itself to the use of two types only has made it possible to concentrate effort on their perfection. The pace is set by the increase in demand. During the year 17,000-hp vertical Francis turbines have been installed at Tallulah Falls to operate under a 600-ft. head.

The developments of recent years are briefly reviewed under four heads:

1. *High Specific Speed.*—The cost per horsepower must be as low as possible. This sets a limit to the development of the low heads. The problem to be solved is to design high-speed, high-capacity runners so that direct connection to generators is possible.

The theoretical term "specific speed"—the speed of a runner which produces unit power (1 hp) at unit head (1 ft.)—has been introduced in practice, and manufacturers now strive to reach the highest specific speeds. Numerous tests made at the Holyoke flume in 1913 have reached values as high as 95 (425 metric), with efficiencies around 90 per cent.

The wonderful progress made in our country has greatly stirred up European engineers. Testing flumes were built by various manufacturers and universities abroad, and authorities are busy with the design of extremely high-speed runners. It can be safely stated that science and practice are on the way to produce runners of specific speeds as high as 200 (850 metric), with efficiencies exceeding 85 per cent.

Thus it will be possible to develop water power under heads heretofore useless for commercial purposes. A test of a single-runner, high-specific-speed, mixed-flow Francis wheel is claimed to have shown an efficiency of 93.7 per cent.

2. *Simplicity and Efficiency.*—Modern hydraulic engineering

endeavors to simplify the design and increase efficiency and reliability.

For multiple arrangement of reaction-type runners, designed with a view to obtaining high speeds, and thus resulting in cheaper generators, there have been substituted large single vertical-shaft runners directly connected to generators.

3. *Consolidation of Systems.*—Large power systems with units of large capacity are becoming more common.

The combination or absorption of small power companies into or by one large concern operating a number of plants tied into the same system has enlarged the scope of requirements and has brought a number of new problems.

USE OF SEPARATE GOVERNORS

In order to obtain two hydraulic ends that may be absolutely separated a further advance has been made by using separate governors, pressure regulators and other accessories. One 18,000-hp, 360-r.p.m., 320-ft. head, double-overhung Francis turbine with two governors, two governor-operated pressure regulators, two butterfly valves, etc., is now under construction for the Pacific Gas & Electric Company, of San Francisco.

It is evident that such a type of unit is of the highest flexibility, safety and economy of operation. One side may be shut down completely or may operate at a constant gate opening with its governors set so as to be ready to close in case of a short circuit; the other side may do the regulating independently.

4. *High-Head Developments.*—High heads generally involve long pipe lines or high velocities of water on account of necessary economy in size of pipe. Either factor involves serious problems of regulation, both of pressure and speed. The former practice was to deflect the jets, either by means of deflecting nozzles or by deflecting hoods. This leaves the velocity in the pipe lines constant and thus reduces the problem of regulation to that of open-flume turbines.

This water-wasting method of regulation is prohibitive whenever a unit operates in connection with storage. The wasting method has been abandoned and the jets are now regulated directly by the governors. This involves the use of pressure regulators and other safety means. It is figured that at Big Creek, Cal., the total waste of water per unit for one complete closing period from full load is only 800 cu. ft.

Efficiency tests made with buckets of the same design as used at Big Creek reached the remarkable figures of 88.75 per cent, and the manufacturer sees no reason why an efficiency of 80 per cent could not be obtained under favorable conditions.

A new type of thrust bearing for vertical wheels has been tested and installed in several large plants. It requires no oil pumps, relying upon the viscosity of the oil to lubricate the bearing surfaces.

The tendency to locate thrust bearings on top of the generators and carry the load of the unit through the speed ring of the turbine down to the foundations has shown a material decrease in yardage of the substructure.

Doing away with oil pumps for bearings and governors at the unit and replacing them with fewer and more powerful pumps has materially lessened the investment, maintenance and operating costs of the auxiliary equipment. Accumulator tanks at the units have supplanted the governor pumps. The new type of bearing previously mentioned requires a gravity supply of oil only. The placing of all auxiliary equipment on the generator floor, thereby doing away with tunnels below the floor, has lessened the yardage of the structure and cheapened the operation of the plant, fewer attendants being needed. The use of water instead of oil for the governor system has resulted in piping of smaller size, as higher velocities can be used.

No material changes have taken place in the design of governor actuators. An interesting plan has been proposed for a medium-head Eastern plant which will be started before the surge tank is erected. The governor-operating cylinder will be disconnected from the guide vanes and the hand-setting device used. The operating cylinder will then be connected to a rheostat and the wheel regulated on the electrical side.

An accident to a Southern plant has forcibly indicated the necessity of separating transformers and other electrical equipment from the generator room and providing efficient means of draining burning oil.

SUMMARY

Modern hydraulic engineering endeavors:

1. To develop water power economically for as low heads as possible. Remarkably high specific speeds have been obtained, and it can be safely forecast that the future will bring results of surprising advance.

2. To simplify the design of low-head hydraulic prime movers, even at the expense of the electrical generating equipment, by the use of large single runners, direct connected to low-speed generators. There is no limitation as to the manufacture of large-size turbine runners, except for reasons of transportation. The maximum shipping size of a single runner was in fact reached during the year, and the largest wheels are now cast in sections.

3. To build units of very great capacity—even up to 40,000 hp —of highest flexibility and reliability. There seems to be no limitation as far as the hydraulic end is concerned; the difficulties now are in the design of the generators.

4. To perfect the problem of economical and accurate regulation. This has been accomplished to such a degree that speed regulation with water-power prime movers has successfully competed with that of steam turbines.

Railway Engineering in 1913

Financial and Regulatory Problems Overshadowed Those of Engineering; Floods of Last March, Federal Evaluation and Electrification Well to the Front in Importance

By L. C. FRITCH
Chief Engineer, Chicago Great Western Railroad

THE year 1913 will go down in history as devoid of any extraordinary development in large railway engineering works. This is directly due to the situation in which railways have been forced by adverse legislation, regulation by commissions, Federal and State, and increased cost of operation and construction consequent upon increased wages and cost of materials without any increase in rates to offset or even partially meet the increased expenses.

While gross earnings in some instances have increased, net earnings have decreased to such an extent that on many important railways the margin is so small as barely to meet fixed charges, leaving nothing for dividends, to say nothing of a surplus available for improvements.

PERFORMING SERVICE FOR LESS THAN COST

It is a significant fact that situations exist on many railways to-day where the cost of performing certain classes of service is greater than the revenue received from existing rates, and under such conditions the more business of this class done the greater the loss to the carrier. This is one of the difficulties besetting the railways in New England, and the same condition applies, in varying degrees, to railway lines throughout the United States.

The greatest need of the American railways to-day is improved terminal facilities; not so much in monumental passenger terminals, many of which, built during the past few years, are not earning sufficient revenue to pay the fixed charges and depreciation on their cost, but rather in extensions and improvements of freight terminal facilities.

The public knows little of the cost to railways of terminal service, especially in freight service. Where hauls are short, with, necessarily, terminal charges at each end and many times at intermediate points, it can be shown that in many instances such charges are equal to or greater than the road haul.

A merchant can readily add a charge to his goods to cover the cost of handling, packing, etc., aside from the actual cost of haulage, but this privilege has been consistently denied the railways until a breaking point has been reached. A common carrier must accept business offered by the public, even though the service is performed at a loss; the only question is, How long can a railway survive before being driven to bankruptcy?

It is not a solution of the railway problem to accuse them of extravagance, neglect, misfeasance and malfeasance in the past. "A condition and not a theory" confronts the railways, and the public must choose whether it will elect to give them a fair deal or listen to exaggerated misstatements by political agitators.

There is no other activity in this country conducted on as high a plane of fair dealing, conformity to law and honesty as the railway. While some past acts may be contrary to laws recently enacted, yet when done they were in conformity with existing laws. The development of our magnificent transportation system could not have been built up under the restrictions now placed upon it, which is evidenced by the fact that investors are seeking other fields and thereby rendering difficult or impossible the carrying out of extensions or improvements in railway works.

TECHNICAL ASPECTS

Turning now to the technical aspects of railway work, the two most notable events in 1913 were the unprecedented floods of March, which put all railroads in parts of the Central West out of commission for several days, and the passage of the Congressional act providing for the Federal evaluation of all common carriers. As in other recent years construction work has been in the direction of grade reduction, multiple tracking, grade-crossing elimination and other additions to existing lines rather than the building of new ones.

Grade reductions carried on during the present year show an ever-increasing tendency to break away from the old location and find a better alignment, with cut-offs and detours to keep through-freight out of congested terminals and give more room for adequate yards. Among the most notable programs under way during the year were those of the Louisville & Nashville in Kentucky, Tennessee and Alabama, those of the Chicago, Milwaukee & St. Paul in Iowa, Minnesota and South Dakota, that of the Erie from New York State west, and the Nicholson cut-off of the Delaware, Lackawanna & Western.

Early in the year the new Grand Central Terminal in New York City was opened. Aside from its magnificence, this terminal, with its two levels of tracks, its loops, its substitution of ramps for stairways, and other novelties is a triumph in engineering fields. The Michigan Central terminal at Detroit has just been completed. In Chicago the proposal to replace the old Union Station with an adequate terminal near the present site called to arms those interested in a more unified arrangement of all terminal facilities in the city, in order to simplify transfer from one road to another and offer less obstruction to the expansion of the business district. Final decision, at this writing, had not been reached. The extensive terminals under construction at Kansas City will be completed early next year.

FREIGHT TERMINALS

As freight terminals and yards are never as conspicuous as passenger terminals, developments along these lines are likely to be overlooked. The year witnessed some advances, however. Considerable was accomplished in the construction of the mammoth Gardenville yard of the New York Central Lines near Buffalo. Near Nashville the Louisville & Nashville is building one of the few hump yards in the South and one of the largest yards in that section. In Chicago most of the railroads have joined in the rehabilitation and enlargement of the old clearing yard, and while the failure of some of the roads to join in this project may reduce its effectiveness, a step has been made to avoid the costly interchange switching in congested terminals.

For the handling of freight into and out of cars, mention may be made of the new steel piers of the Norfolk & Western and the Chesapeake & Ohio at their respective tidewater terminals. The pier of the Norfolk & Western is practically completed. Its capacity will be far in excess of that of any other pier on the Atlantic seaboard, and the work will be done almost entirely by gravity and electric machinery.

Notable railroad bridges put under construction during the year are noted elsewhere in this issue.

Early in December the headings met in the 3-mile Mount Royal tunnel at Montreal. This ambitious project, by which the Canadian Northern gets into the heart of Montreal, has been put through in record time. In the summer the contract was let for the construction of the 5-mile tunnel of the Canadian Pacific at Rogers Pass in the Rocky Mountains. More recently a board of engineers has reported favorably on the joint project of the Denver & Salt Lake Railroad and the city of Denver to build a 6-mile tunnel through James Peak in Colorado.

ELECTRIFICATION

Steam-railway electrification has made a long step forward during the year, not so much on account of electrification done as by reason of its adoption for other than metropolitan districts. The most noteworthy instance is the decision of the Chicago, Milwaukee & St. Paul to electrify 440 miles over the Rockies. Other roads deciding to electrify mountain divisions are the Denver & Rio Grande and the Norfolk & Western. Progress in electrification is also marked by the extension of the New York, New Haven & Hartford electric service from Stamford to New Haven, and the decision of the Pennsylvania to electrify certain of its lines in the Philadelphia district. Direct current and alternating current both retain their advocates; the low-voltage direct current, however, is giving way to a higher voltage. The St. Paul has just decided to use the 2400-volt direct-current system. The Butte, Anaconda & Pacific's electrical installation has been put into service during the year, also using the high-voltage direct-current system.

Grade-crossing elimination has proceeded wherever conditions demanded and arrangements for equitable division of expense obtained. In such work much has been accomplished in the artistic treatment of bridges and retaining walls. Evidence of this is found in new work of the Pennsylvania in Philadelphia, of the Delaware, Lackawanna & Western on its Montclair branch and of the Boston & Maine at Lynn, Mass.

In maintenance circles the year has been characterized by the growing use of machinery and by the organization of forces on a unit basis, with bonuses for efficiency.

The March floods afforded more opportunities for emergency engineering than the railroads have ever before had. The suddenness and completeness with which entire divisions were put out of business made it difficult at first even to learn the extent of the damage done. The affected railroads had to pool such of their lines as escaped injury, and the operation of work trains over the devious routes had to be subordinated to the prompt handling of trains carrying supplies to the stricken communities. Engineers from the untouched divisions were pressed into service, pile drivers were borrowed from other roads, and forces worked night and day to reopen the lines. The fact that no serious accident occurred during the period of disturbance speaks well for the railroads' ability to meet emergencies.

The spirit of regulation was as active as ever, as is shown by the introduction of 1395 bills in forty-two State legislatures; 230 of these bills became laws. Public utility commissions were created in Pennsylvania and Illinois and the old railroad commissions in Massachusetts and Indiana were replaced by new commissions with broader powers. The opinion is freely expressed that if the Interstate Commerce Commission denies the present application of the railroads for permission to raise freight rates Government ownership will have made a great gain.

FEDERAL EVALUATION

Last winter Congress instructed the Interstate Commerce Commission to evaluate all common carriers doing interstate business. Four bases of evaluation—sale value, original cost to date, cost of reproduction new and cost of reproduction less depreciation—were specified, Congress not stating which one should be used for rate-making purposes. An advisory engineering board was created. After several months devoted to a general study of the matter the board has divided the country into five districts, district engineers have been appointed for each, and district offices have been opened. To protect their interests and keep in touch with the situation the railroads have created a representative board called the Presidents' Conference Committee. Many of the roads have also created valuation departments. Tentative specifications for maps, profiles and specifications to be furnished by the railroads have been thoroughly discussed by the interested parties, and while the final draft has not yet been given out it is thought that the main difficulties have been smoothed over. In June civil service examinations were held for sixteen positions intended to cover the range of experience required for the engineering work. No appointments have yet been made.

Among the engineers there has been much discussion of the proper basis of evaluation for rate-making purposes. Of the four bases above mentioned engineers have rejected the first as unfair and the second as impossible to obtain. In June, in the celebrated Minnesota rate case, wherein the railroads sought relief from a reduction in intrastate rates ordered by the State, the U. S. Supreme Court ruled that reproduction cost loss depreciation was the proper basis for rate-making purposes. Some think that that decision, regardless of its correctness, settled the matter. Others, however, insist that the railroads did not present their case well, and that ultimately when the matter is better handled the court will accept reproduction cost new as the right basis.

In Canada, while little new work was undertaken, work progressed steadily on the large transcontinental projects previously started. The northern terminal for the Hudson Bay Railway was decided upon, and the work was pushed steadily forward. Work was also pushed on the terminals of the Canadian Pacific at Vancouver.

Concrete and Reinforced Concrete in 1913

Research Has Resulted in Valuable Data on Building Members and Bridges, and Indicates That Still Greater Structural Efficiency May Be Expected

BY SANFORD E. THOMPSON
Consulting Engineer, Boston

DEVELOPMENTS along lines of concrete construction during the past year, while showing no extraordinary advances, have been steady and continuous. From the standpoint of design one of the most encouraging features has been the increasing recognition of the recommendation of the Joint Committee on Concrete and Reinforced Concrete as a standard for construction. A few notable tests have been made which throw light on special features of design and indicate definite lines along which investigations may be continued in the future. In construction, progress is toward larger and more important structures than hitherto, but usually along sound and rational lines.

PROGRESS ON IMPORTANT CONCRETE STRUCTURES

The year has marked the completion of the dam, nearly a mile long, across the Mississippi at Keokuk, Iowa, and of the immense plant of the Mississippi River Power Company at that point. The Los Angeles Aqueduct, 240 miles long, is important not only for the size of the undertaking but for the use of tufa cement, that figured so largely in its construction, with results which appear to be satisfactory both from the structural and economic standpoints. The Catskill Aqueduct for the supply of water to New York City has made satisfactory progress.

The Arrowrock Dam on the Boise River, Idaho, 351 ft. high—said to be the highest in the world—is well under way. The concrete locks at Panama have been completed and small vessels have passed through the canal. The Yardley viaduct, across the Delaware River on the Philadelphia & Reading Railroad, more than 1400 ft. long, is one of many long viaducts completed in 1913.

One of the most notable buildings now being designed for construction in reinforced concrete is the new Technology on the banks of the Charles River at Cambridge. The main building, described in the Engineering Record of Nov. 15, 1913, will have some 850,000 sq. ft. of floor area, and will require more than 50,000 cu. yd. of concrete. It will be composed of about sixteen divisions, each large enough to form a complete building in itself.

In the South, where developments of all kinds are taking place, hotels, factories, office and public buildings, and railroad terminals, to the value of many millions of dollars have been built in concrete in the last year.

Limitations imposed by cost, which in most cases prohibit the attainment of even ordinary architectural attractiveness, have restricted the use of concrete in houses of average size. For fireproof dwellings on a more pretentious scale reinforced concrete is gradually taking a prominent place. At the other extreme, for workingmen's houses, it has been found possible to cast groups of small houses, all alike and very plain, that are satisfactory from the standpoint of use and are low in first cost and in upkeep. These have been built recently in various localities—one group in Nanticoke, Pa., another in Oklahoma, while similar development is taking place in France and Ireland. In Ireland 39,000 of these houses have been built in the last three years.

CONCRETE ROADS

The advance in concrete-road building has attracted perhaps more public attention than any other department. The conference at Wilmington, Del., held in the fall, was devoted almost entirely to concrete roads. Next month a national conference on concrete-road building will be held in Chicago. Reports will be presented by fifteen committees, which have been delegated to study and report on specific features of concrete-road design and construction. For a long time paving foundations have been built of concrete, but its use for the wearing surface or for the entire pavement has been more recent. The development of well-defined rules and specifications will tend to obviate to a considerable extent the danger of failure through improper methods of construction and use of aggregates not properly tested.

Construction plants and methods of construction are receiving more and more attention, especially with a view to reducing construction costs by the adoption of well-thought-out plant design and through more efficient management.

Reinforced concrete is distinguished from other building materials because it is usually built continuously, which presents the difficulty of making full-sized tests except at large expense. A new method of testing has been brought out by Prof. A. N. Talbot, which has permitted the correlation of test loading and actual results in construction. The building is loaded, but instead of simply finding the deflections, actual stresses are measured in the concrete and steel. Such tests as these have tended to emphasize still further the value of the report of the Joint Committee, which in its essential features is gradually being adopted in nearly all the large cities as a part of the building laws.

The design of reinforced-concrete footings, which are indeterminate from the standpoint of pure theory, has been placed on a satisfactory basis as a result of full-sized tests. Again we are indebted to Prof. Talbot for the admirable conclusions presented.

Interesting experiments affecting the design of reinforced concrete arch bridges have indicated the range in temperature which may be expected in such structures. (Bulletin 30, Engineering Experiment Station, Iowa State College.)

Relative tests made by Bach in Stuttgart, Germany, of beams with bent bars, with stirrups, and with combinations of the two tend to confirm the effectiveness of these types of web reinforcement to resist diagonal tension.

OTHER TESTS

A test near Chester, Ill., extending over thirteen months, of a 40-ft. through highway bridge of reinforced concrete, two and a half years old before testing, throws an interesting light on the behavior of such structures under load. The bridge carried from nine to thirteen times the maximum load to be expected in service, and the results further indicate the increase of strength and stiffness to be expected of reinforced concrete with the lapse of years. (See "Proceedings" of the American Society for Testing Materials, Vol. 13, 1913.)

A new test for cement—the autoclave test—in which cement is subjected to high pressure and temperature, has received considerable attention, but the results thus far do not warrant its adoption as a standard test.

A plan for more systematic investigation of mooted points in laboratory testing has been adopted by the committee on concrete materials of the American Concrete Institute. Duplicate instructions for tests to cover specific features were sent last year to various laboratories, and the results are being correlated in order to present them to the Chicago convention of the institute in January.

LESSONS FROM EXPERIENCE

In view of the phenomenal growth in concrete construction and the continued development expected in the future, attention may well be called to the lessons to be drawn from past experience. The theory of reinforced concrete is now so thoroughly standardized that it is possible to design in this material with an accuracy but little surpassed by steel. Yet a large number of designs have been brought out even within the last year with certain features that are absolutely opposed to correct engineering principles.

New failures have been traced directly to poor design, but in many cases it has contributed indirectly. Incorrect design has been the direct cause of most cracks, which, although not dangerous, mar the appearance of structures. Notice, for example, in any steel-frame office building with a reinforced-concrete floor the cracks which occur over nearly every beam, simply because of failure to place properly the horizontal steel in the top of the slab over the support.

THE FUTURE

As a foreword to the future, based on lessons from the past, we may summarize as follows the most important requirements in reinforced concrete and in concrete construction generally:

1. Careful attention in design to the fundamental principles of mechanics of continuous beams and rigid frames, especially at supports and connections.

2. Proper provision for temperature changes either by reinforcement or by expansion joints.
3. Definite requirements in all specifications that the sand shall be actually tested in a laboratory with the brand of cement to be used in the structure, and shall be rejected if it does not reach the standard strength in tension and compression.
4. Thorough supervision of construction as relates especially to:
   a. Accurate placing of steel.
   b. Exact proportioning of the aggregates and cement.
   c. Proper consistency.
   d. Care in removal of forms, especially in cold weather.

These are all simple points, but the neglect to observe one or more of them has been the cause of nearly every failure of a reinforced-concrete structure. These points do not, of course, include features which must be taken into consideration in special cases.

Under sound engineering principles the use of concrete will proceed in a field continually widening, and in larger and larger structures. The record of to-day is being eclipsed and forgotten to-morrow. As this development continues unbroken, many careful investigators are going deeply into the minor undetermined points which affect the economy of design and the permanent resistance to the action of the elements. As a result we are fast accumulating data along lines not yet fully understood.

Status of Irrigation Development

Complete Stagnation Demands Readjustments in Arid Region, Legislation to Prevent Unsound Ventures and Settlement of Pending Water-Right Controversies

By GEORGE G. ANDERSON
Consulting Engineer, Denver

BROADLY reviewed, the year 1913 has been a period of almost complete stagnation in irrigation development. Practically no new works of any magnitude have been commenced and activity has been confined solely to the finishing of projects previously under way. Even among the latter only those were in progress where the financial arrangements had already been completed or were possible of negotiation within the organizations themselves, thus being independent of the prevailing conditions in the money market.

REASONS FOR STAGNATION

General hesitation to embark in new industrial enterprises has, in part, been responsible for the cessation of activity, but the present condition is most largely due to a widespread distrust of irrigation securities. That distrust has followed upon the failure of a number of irrigation projects to meet their financial obligations—not confined to any particular locality nor to any one of the various classes in which these projects are grouped.

After a full decade of feverish activity the inevitable reaction has set in, commencing really prior to the beginning of the year and coming actually later than could have been intelligently forecast.

The present conditions are not due solely to the pricked bubble of immature or impossible enterprises, much as they have contributed to the result. The trouble is that, following all effort at reclamation by irrigation or even the most attractive and commercially sound enterprises, there must come a non-revenue producing, or insufficient-revenue-producing period, consequent upon the necessarily large expenditures. In fact, the commercially sound enterprises are, perhaps, most acutely affected.

This is no new condition. Every preceding effort at the agricultural development of the West, extending over fully fifty years, encountered it, and conquered it, if at all, by the slow process of the years and the gradual evolution of a special farming class. From the experience of these previous ventures, written plainly enough into the records, the immediate consequences of the extensive development of the last ten years could have been foreseen and discounted, if not in full, certainly in such large measure as would have avoided the position in which many irrigation investments now find themselves. In this, as in other relations of life, the new generation has been prone either to ignore or to despise the experience of the past, only to find itself compelled to retrace its steps much in the same line as did its predecessors.

A generation ago that meant almost complete reorganization, a reduction of capital investment, and readjustment of the enterprises themselves to the actual growth of rural population and to the requirements of these new communities. It would seem that similar policies must be pursued at the present time for further advancement in irrigation development.

EXPERIENCE OF U. S. RECLAMATION SERVICE

The experience of the U. S. Reclamation Service amply indicates that such reorganization and readjustment are inevitable. Initiated ten years ago on a program that superficially indicated the return of moneys expended within a period of ten years, thus creating a "revolving fund" making possible the continued extension of governmental aid in reclamation by use of distinctly limited expenditure, the "returns," so far, have been entirely negligible. Apart altogether from the consideration of some injudicious expenditures, and expenditures on single enterprises greater than could possibly have been returned within a specified time, the serious difficulties confronting the operations of the Reclamation Service are the sparse settlement of completed enterprises, the inability of these to meet the expenses of operation and maintenance—to say nothing of returning the capital expenditure—and, as serious as any other feature, the ignorance of such settlers of all the conditions of irrigation farming.

To a greater or less extent these conditions affect all classes of private companies engaged in irrigation enterprise, with the added force that operation and maintenance costs and interest upon expenditure must be met with ready cash and without the assistance of the United States Treasury.

Coincident with the close of capital expenditure has come a strongly marked decline in the movement to the land. This is attributable largely to the general reluctance to embark on new ventures, and, perhaps oddly enough, affects the Reclamation Service's enterprises more than those of private corporations, though with sufficiently serious results to the latter.

RESULT OF PERIOD OF STAGNATION

The immediate result of the period of liquidation will be healthy, if drastic, involving probably heavy loss of investments already made, postponement of further investment for a considerable period, and increased caution in thoroughly legitimate enterprises. Of the latter, both public and private, there will continue to be enough to exercise the energy of the engineer, as it is still an axiom that wherever ample water supply can be attached to good land with reasonable expenditure there are abundant compensation for capital and desirable homes for the settler.

To better insure the capitalist and home builder alike, many conditions can be materially improved in the period of inactivity in construction which has set in. Legislation clearing away most of the anomalies surrounding the business, both for capitalist and homeseeker, is urgently required throughout the arid region, not the least important of which should be the rigid regulation and control by State authorities of attempts to build up such enterprises in districts wherein there are no adequate waters, even though that may seem to be a tardy closing of the door after the horse has been stolen.

More extended and accurate hydrographic information is essential to further development, and should be secured alike by National and State bureaus. Increasingly better methods in the use of water by the consumer have to be evolved, even if carried to the extent of reducing rights now apparently vested, but not adequately used or actually beneficial.

SETTLEMENT OF DISPUTES OVER WATER RIGHTS

Most important of all, perhaps, is the speedy, satisfactory and decisive termination of all disputes among States over the use of water. In the States themselves controversies between the Government and the water user must be terminated, even if the enactment of a uniform National water law may be regarded as a Utopian dream.

These are readjustments of vital importance that may very profitably be carried out in a period of general readjustment that has begun and may continue for some time.

Tendencies in Highway Development

Progress Toward More Centralized Highway Administration and in the Construction of the Stronger Roads Required by Modern Traffic

By WILLIAM D. SOHIER

Chairman, Massachusetts Highway Commission

ALL over this country there has been developed during the last few years a tremendous and insistent demand for good roads. State after State has considered this subject, has passed legislation, has made large appropriations and has begun to develop an organization to secure better roads. The public is just beginning to realize the tremendous yearly loss in high transportation costs caused by bad roads and the tremendous waste due to inefficient methods, poor materials, bad design, and, above all, inadequate maintenance.

The movement is not confined to this country only, but is very strong abroad as well.

New Requirements Have Developed

Naturally what is required to secure good roads differs in different parts of the country. Some of the States need the improvement of existing roads and others the development of an entirely new highway system. Many require both.

The motor vehicle—automobile, motorbus, motor truck and traction engine—is rapidly making an entire change in our transportation system. It makes necessary through routes, and by transporting passengers and freight over long distances it rapidly destroys country roads that were formerly entirely adequate.

Many routes which were merely little country roads, with only 20 to 30 teams a day, have now become main highways with 200 to 500 vehicles a day, many of them 3 to 6-ton trucks. Not only is the road itself, foundation, material and surface, entirely inadequate to carry this traffic, but the country culverts and bridges, designed to carry often only 3 tons, and commonly only 6 tons, are not strong enough, and are being destroyed. Evidently new and stronger roads and bridges are an absolute necessity.

To secure this in most places requires not only the development of a highway system, carefully designed and under competent and trained engineers, but also a redistribution of the cost of construction and maintenance. The traffic which was entirely local, confined to the teams from a few of the neighboring towns and cities, has become interurban and interstate—almost National—in character.

The country town no longer furnishes the traffic, and it does not possess even a fraction of the money that is required to build and maintain the necessary roads. These facts become more and more evident year by year, and the same conditions are becoming the rule abroad.

Conditions Abroad

We are more and more progressing toward the centralized French road system. The 24,000 miles of national roads cost in France, with its long hours and cheap labor, an average of $12,500 a mile to build, and the 371,000 miles cost more than a billion and a half dollars to construct. The annual maintenance charge has been $45,000,000 a year, and more is now necessary.

In England the Government is now appropriating from $5,000,000 to $7,000,000 a year in helping to improve main highways, but only for well-designed improvements under standard specifications determined by the engineers of the Road Board, the Government appropriations being largely supplemented by local appropriations.

The county councils are appropriating and the county engineers are spending annually more than $14,000,000 for the improvement, reconstruction and maintenance of the main highways; London and its surrounding county boroughs, $10,000,000 a year more, and the local communities, $19,000,000. The yearly cost of the 150,000 miles of road in England and Wales for maintenance, including interest, is nearly $76,000,000 a year.

To-day the most important consideration in England is how to reclassify the roads, how redistribute the cost of reconstruction and maintenance so that the necessary money can be secured and the necessary expense fairly placed upon the persons who use the roads and the communities which receive the benefit, and not continue to have an inequitable and unbearable burden upon the local community, whose few inhabitants make little use of the highway and secure but little benefit from it.

The same tendency is plainly evident here in the activities of counties and States in highway matters. Moreover, the necessity for new highway systems and for a wider distribution of the burden of building and maintaining them has led to a Nationwide demand for National aid.

Centralization Needed

If satisfactory roads are to be secured the work must be carefully planned and the roads laid out and constructed by educated and experienced road engineers and constructors. To accomplish this the authority over the main roads and roads of more than local importance must be so centralized that a system can be developed and enough expenditure involved to justify the employment of such engineers or constructors.

In most of the States this movement has resulted in the appointment of a State highway board or engineer. No doubt in a year or two every State in the Union will be so provided.

So much money has already been appropriated for the construction of roads, not only in this country but in Canada, and so many new highway boards have been appointed, that the supply of engineers experienced in road work and having the executive ability to organize and run a highway department is even now far below the demand. Already some of our universities and technical schools are establishing new courses in highway engineering. Experience, however, it must be remembered, is a necessary adjunct of book knowledge.

Competent engineering advice is of prime importance. Upon it depends our success or failure—whether we waste millions and secure mud, with a tremendous bonded debt burdening our children, or good roads, adequately maintained, saving the community every year in transportation several times their cost for interest and maintenance.

Stronger Roads Needed

In the older States and countries the roads have required, and now require, not only stronger and better surfaces but adequate foundations. Wherever motor traffic is heavy, all engineers recognize that some form of bituminous binder in the top 3 in., or as a surface, is not only economical, but is absolutely essential if the road is to be preserved for even a few months. This is true not only of waterbound macadam roads but also of gravel roads.

Many interurban roads that formerly had only country travel are now rapidly having city traffic develop over them. In the near future this will require a pavement, possibly a concrete base. Thicker bases, up to 9 in., are being advocated for heavily traveled streets in London, while in other parts of England some 40,000 miles out of 150,000 miles of road have this year been coated with a surface coat of a bituminous material. In France the papers state that the department has asked for $50,000,000 to be used in the next eight or ten years in resurfacing with a bituminous macadam about 6000 miles of their national routes (out of 24,000 miles).

In many parts of the country, especially where stone or gravel suitable for building roads cannot be obtained at a reasonable price, the road builders are forced to use other materials. In some places brick is available and cheap. In other localities cement and concrete roads are being constructed. In some others, like California with its low-priced asphalts, a 4 to 6-in. concrete base with a bituminous 2-in. top, made of local asphalt, is being used. In some parts of the country shells or sand only are available, and roads are being built of these materials.

When all is said and done, however, the available local material, in proper combination with other materials, or in its natural state, with proper alignment and grade, suitable culverts and bridges, and, above all, adequate drainage and constant maintenance, will have to carry the traffic over the vast majority of the roads of the United States for this generation.

Conclusion

The development of the best road system that we can afford, properly constructed and adequately maintained, requires a comprehensive highway system, carefully organized and properly financed, not only for its construction, but—much more important—for its maintenance. This again absolutely requires educated, trained and experienced men to plan, systematize, and supervise both construction and maintenance. In my judgment public opinion is rapidly coming to these conclusions.

Refuse Disposal and Street Cleaning

Advances of the Year Consist Chiefly in Better Appreciation of Costs and in Scientific Study of Collection and Operating Methods

By SAMUEL A. GREELEY
Formerly Superintendent, Milwaukee Incineration Plant

REFUSE-DISPOSAL practice during 1913 in this country and Canada has shown unusual and marked activity. Of the sixteen cities in the United States which in 1910 had a population of 300,000 or more nine have had the refuse-disposal problem actively under consideration, or have had new refuse-disposal works under construction. In New York, Chicago, Newark, N. J., and Toronto sanitary engineers have been engaged in making investigations looking to improved methods. In Philadelphia, St. Louis, Boston, Detroit and Washington the city officials have made similar investigations, while San Francisco has completed one refuse-incinerating plant and is constructing a second one.

Among cities with populations of from 100,000 to 300,000 similar activity has been witnessed. Kansas City, Atlanta, Paterson, N. J., and several others have entered into contracts for new refuse-disposal works. At St. Paul an investigation is under way.

Even among the smaller cities improved practice in refuse-disposal has been demanded. Springfield, Mass., Youngstown, Duluth, Schenectady, Savannah, Charleston, Racine, Huntington, W. Va., and many smaller places are building or have built refuse-disposal works, or have the matter under advisement.

REDUCTION PROCESS

One of the chief objects of the interest displayed during the year has been the reduction plant. Except in a few cities, reduction plants are operated by private contractors under short-term agreements with the municipality. In several cases during the last year these contracts have been up for renewal. This question has produced much public discussion. As a result a great deal of information about the reduction process has come to light, particularly as to the cost of operation, the fair return to the contractors and the net cost to the city of short-term contracts. This was notably so in New York, where under a contract signed in July John J. Hart agreed to pay the city for the final disposal of the garbage of the Boroughs of Manhattan, The Bronx and Brooklyn a total sum of $487,500 for a five-year period, as against a payment by the city to the Sanitary Utilization Company, under the old agreement, of $50,000 a year. Similar evidence was brought out during the investigations at Chicago and Philadelphia and by bids received at Los Angeles and Dayton. This evidence has been corroborated by the continued successful operation of the municipal plants at Cleveland and Columbus.

Advances in the construction details of reduction works have not been so prominent. New municipal reduction works have been built at Schenectady, but their operation has not resulted in any new developments. There has, however, been considerable discussion as to methods available for the destruction of odors and obnoxious gases produced by the reduction process, and this discussion has, on the whole, brought the reduction plant into a more favorable position before the public. It has been found that a close confinement of the gases produced during the operation and their subsequent combustion greatly reduces nuisance. Recent specifications have been very strict in this regard. The reduction method has, therefore, progressed materially during the past year, due to lower net costs on new contracts and to a more thorough understanding of the possibility of reducing odors.

INCINERATION

The disposal of mixed refuse and garbage by burning has made steady progress. Municipal incineration works have been built or put under construction at San Francisco, Clifton (Borough of Richmond, New York City), Paterson, Atlanta, Savannah, Halifax, Racine and Havana. This progress has been along substantial, constructive lines, and interesting new details have been developed on a practical working basis. Chief among these details are the mechanical devices for charging garbage and refuse into the furnace and for removing the resulting clinker and ash. The furnaces completed during the year at Clifton and Paterson are equipped with such apparatus. On a smaller scale, an interesting charging device has been put into operation at Oak Forest, Ill. This is in connection with a furnace designed to burn garbage with coal and consists of a pusher or ram which delivers a small charge of garbage into the furnace from a closed storage hopper. There is a similar plant at Racine.

The utilization of the by-product steam from high-temperature-refuse incinerators has not been developed to a general working basis. Electric generators for utilizing the power have been installed in the incinerator at Milwaukee, and were put in operation during December. With this exception no new record of actual steam utilization on a full output basis has been made in this country. Nevertheless, estimates for proposed new works have included a revenue from the power.

CLINKER UTILIZATION

Clinker utilization has not progressed materially. The new incinerators at Clifton and San Francisco have been equipped with clinker-crushing machinery and results should be available during the present year.

The advances recorded above in both reduction and incineration works have led to a favorable consideration of a combined reduction and incineration system for large cities. Investigations at New York by the Board of Estimate and Apportionment resulted in a recommendation of this system, and it is being studied in connection with the extensive improvements now being projected at Toronto. Both types of plant have been installed during the year on Spectacle Island, in Boston Harbor, for the service of the city.

REFUSE COLLECTION

The importance of the collection of refuse, as the most costly part of the system, has been more generally appreciated than in the past. In cities where careful investigations for new works have been made the effect of the method of disposal upon the cost and efficiency of collection has been included. Valuable data on this point, including time studies, have been secured and recorded with commendable detail by the efficiency division of the Chicago Civil Service Commission and by investigators at Trenton.

Especial consideration has been given to methods for increasing the mechanical and personal efficiency of street-cleaning departments handling refuse disposal. This has included improved methods of house treatment, in order that there might be co-operation between the householder and the collection department; better wagons, better methods for recording costs on a uniform unit basis, and the performance of work on a sliding scale arranged to fix responsibility for inefficient work.

STREET CLEANING

No radical development in street-cleaning work occurred. A great deal of good information has been presented and existing practice has been studied very thoroughly. A better and more widespread understanding of the requirements is the most striking result of the year's activity.

With all this activity and progress, one special line of error cannot be passed over without comment. City councils have too often failed to appreciate the engineering element in refuse-disposal work and have undertaken to solve their own local problems without competent engineering assistance or by limiting their own engineers to inadequate funds. Such has been the situation in Chicago, Philadelphia, Detroit, Kansas City and elsewhere. In all these cities an attempt has been made to let contracts for refuse-disposal works before adequate investigations were made or reported, or on weak specifications. Failure to secure satisfactory bids or to proceed with a contract after receiving bids occurred once each during the last year in Detroit, St. Louis, Philadelphia and Kansas City, and three times in Chicago. This uncertainty places a considerable burden upon the contractor and increases the cost of the work of the city. One contractor who does work chiefly in smaller cities states that his bids include an item for contingencies equal to his estimate of the construction cost. An early and adequate engineering consideration of the local problem, therefore, would mean a material saving to the municipality.

The year 1913 has furnished much of value. In the future the engineering and economic aspects of refuse disposal should receive more consideration, and by a proper application of scientific principles the possibilities for progress which have become apparent during the last year should be realized in practice.

Ornamental Portal at Commonwealth Avenue and Kenmore Street

Boylston Street Subway in Boston

Two-Track Tube Which Occasioned Unusual Difficulties on Account of the Made Ground on Which It Is Built

By LAURENCE B. MANLEY

Assistant Engineer, Boston Transit Commission

THE Boylston Street subway now being constructed by the city of Boston through the filled land of the Back Bay is the outcome of various attempts to reduce the increasing traffic congestion and provide a more rapid means of transportation for 100,000 people living in this district and in towns to the west and south. Previous endeavor to accomplish the same result resulted, in 1909, in the authorization of the Riverbank subway, which was to extend between practically the same terminal points as at present, by way of the bank of the Charles River. For various reasons this was never built, and its warrant was revoked by the act creating the Boylston Street subway in 1911. In its present form the subway will, through its connection with the Tremont Street subway, provide for the quick passage of surface cars from Brookline, Brighton, Newton and adjacent towns to the heart of the city.

This new subway, with two tunnels in other parts of the city, the Dorchester tunnel and the East Boston tunnel extension, is being constructed under authority from the Legislature by the Boston Transit Commission, the combined projects forming an extensive addition to the existing subway system. The whole of the system is owned by the city and leased to the Boston Elevated Railway until 1936 at varying rates—the later subways, including that under discussion, at an annual rental of 4½ per cent of their net cost.

GENERAL ROUTE

As originally defined by the Legislature, the Boylston Street subway was to extend from a point near the junction of Commonwealth Avenue and Beacon Street to the corner of Park and Tremont Streets in the center of the city, a distance of nearly 2 miles, following the route shown on the general map. The act prescribed stations at Massachusetts Avenue, at Copley Square, at or near the corner of Boylston and Tremont Streets and at Park Street, and permitted such remodelling of the existing Tremont Street subway as might be necessary to obtain the best arrangement of tracks and stations in combination with the new subway.

In the spring of 1912, however, before construction work had reached the Common, strong pressure was brought to bear on the Legislature to change the inbound terminus of the subway from Park Street to Post Office Square. This change, which would involve a large additional expense and much delay in completing the work, is still under consideration. Meanwhile a temporary connection with the tracks of the Tremont Street subway is under construction at Park Square. This will permit early use of the portion of the Boylston Street subway already constructed, will allow future extension to either Park Street or Post Office Square, and will provide an opportunity for switching cars between the tracks of the two subways without crossings at grade, so that, in case the Post Office Square route is finally decided upon, the Boylston Street subway cars can also be sent by way of the Tremont Street subway to Park Street.

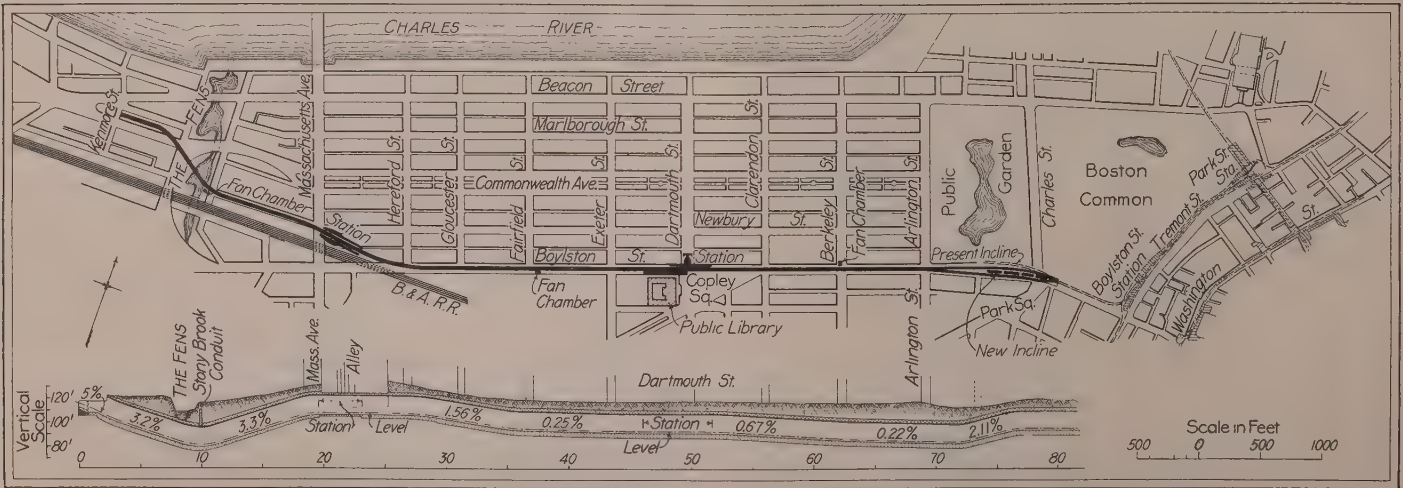
GENERAL FEATURES

That portion of the Boylston Street subway now under construction is a reinforced concrete two-track structure, 8,000 ft. long with stations at Massachusetts Avenue and at Copley Square. It will cost when completed about $4,500,000. The work, which has been divided into five contract sections, has been pushed as fast as a settlement of the details of construction would permit. The act authorizing its construction was signed June 30, 1911, and after nine months spent in making surveys and plans, ground was broken for the first section in the following March. Since that time a force averaging 800 men, working night and day on that part of the work situated in Boylston Street, has steadily prosecuted the undertaking, so that it is now 80 per cent completed, and is expected to be placed in operation early in the summer of 1914.

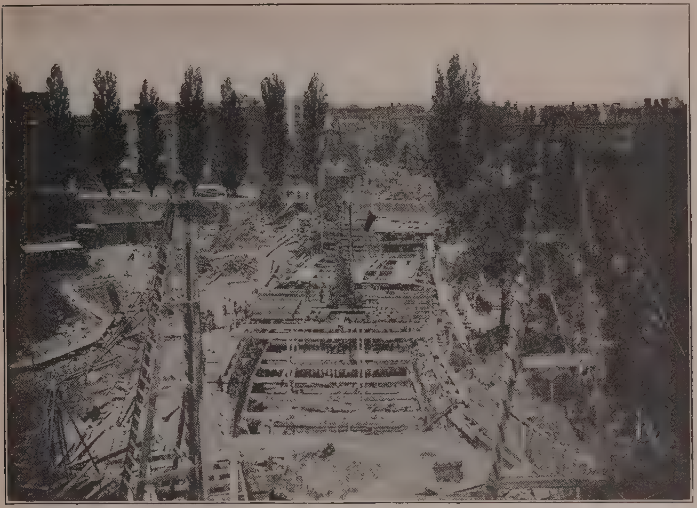
GEOLOGY

The wet and yielding character of the ground of the Back Bay district has necessitated different details of design and different construction methods from those which have obtained in other subway work in Boston. The district was originally a mud flat, covered with water at high tide, and was reclaimed between 1862 and 1872 by filling in with gravel. In general the geology of this district is as follows: Below the gravel fill, which is 18 or 20 ft. in thickness, is a layer of black silt 6 to 20 ft. deep overlying a deep bed of blue clay. In a deep boring at Dartmouth Street this clay was found to be 100 ft. in thickness, resting on boulders or bed rock.

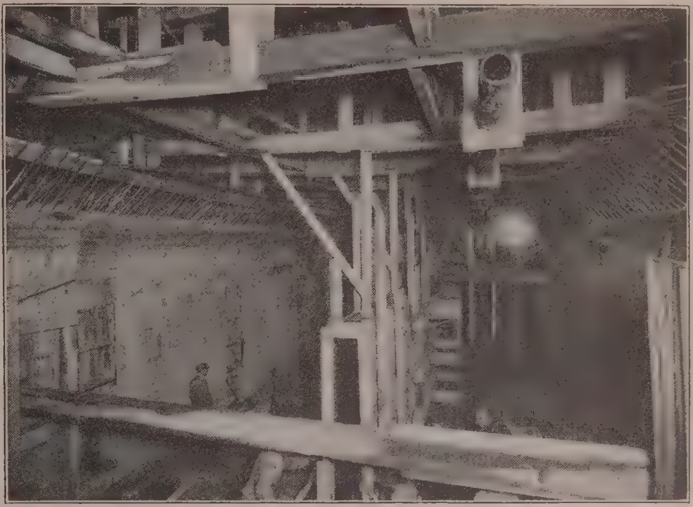
West of Dartmouth Street a stratum of



Map of Back Bay and Location of Boylston Street Subway and Temporary Connection with Existing System



Construction Operations in Bottom of Fens Pond



Partly Completed Subway under Newbury Street

clean sand and gravel from 7 to 18 ft. in thickness is found between the silt and the clay. This sand layer carried large quantities of water strongly impregnated with sulphuretted hydrogen gas, the fumes from which have seriously affected the comfort, health and eyesight of the workmen. At several points pockets of peat have been encountered below or in the sand. In the peat at Church Street, which was 28 ft. thick, stumps of pine trees standing in their original position have been found, one of which, 15 ft. below mean low water, is a convincing witness of the gradual subsidence of this region.

The silt is composed of fine sand and clay colored with organic matter, and was evidently deposited through the quiet water of the bay. It is soft and compressible, but impervious to water when dry and when not heavily loaded will stand without support with almost vertical banks 10 ft. high. The clay, evidently of glacial origin, is hard for the upper 10 ft. of its depth and soft and plastic below.

On account of the soft character of the underlying materials, the surface of the streets of the filled district has undergone a general settlement in addition to a more marked local settlement due to heavy loading and lack of lateral support. The average settlement of the surface of Boylston Street during the last ten years has amounted to about 3 in. The buildings, which are almost universally set on wooden piles, have also settled, in some cases to a serious extent.

The ground water throughout the district stands from 5 to 8 ft. above mean low water. Altogether, it will be seen that the ground is exceedingly unstable, requiring heavy sheeting and pumping during construction, and furnishing an unsatisfactory foundation for the subway structure.

WESTERLY SECTION

The first contract section begins at the incline at Kenmore Street and winds downward through the Parkway, passing through the Fens Pond and under Stony Brook conduit, thence rising in Newbury Street to the first station at Massachusetts Avenue, 2000 ft. from the start.

The open incline at the beginning of the subway in the Commonwealth Avenue Parkway, overlooked by imposing residences on both sides, has been treated in a dignified manner in accordance with plans furnished by Mr. A. A. Shurtleff, the landscape architect for the Park and Recreation Department. Descending on a 5 per cent grade between rough-pointed concrete walls, the tracks enter the subway beneath an elliptical portal arch, the whole surmounted by an ornamental balustrade of concrete and surrounded by trees and flowering shrubs. To afford an early warning of approaching cars, the incline for its first 2 ft. is widened by right-angled offsets in its sidewalls, giving a total width of 36 ft. between the ornamental light and trolley poles at the beginning of the balustrade.

The balustrade is of a conventional heavy-post-and-baluster type and has a height of 3 ft. 4 in. between the top of the rail and the coping of the side walls. The posts and rails are reinforced with small steel rods, and were cast in position with shrinkage joints at each post. The ornamental trolley posts were molded around standard steel trolley poles previously set in the wall, the more intricate portion of the work being cast in plaster-of-paris molds coated with shellac. The balusters were cast in sand molds at the shop of the contractor for the balustrade, the Emerson & Norris Company, and were set in position on the bottom rail before the top was cast.

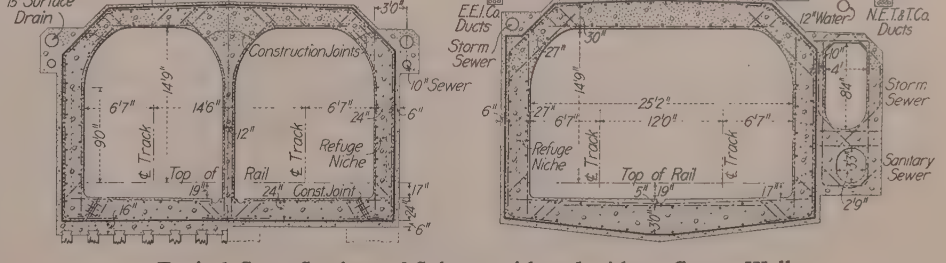
All concrete in trolley poles and balustrade is composed of one part of cement to two parts of fine crushed Quincy granite, from which the dust had been screened, the dark aggregate being revealed by scrubbing off the surface cement after a set of about twelve hours. The texture and color of the resulting concrete surface when viewed from a short distance closely resemble that of cut granite, which, combined with the harmonious proportions of the balustrade, gives it a most pleasing appearance.

USE OF CENTER WALL

On account of the depth of cover over the subway and the unstable character of the earth beneath a continuous center wall was deemed desirable through this portion of its length. The cross-section shown gives the dimensions on a tangent; on the curves the width is greatly increased on account of the requirement of 1½ ft. clearance outside of an assumed car 70 ft. long and 10 ft. wide with a tip due to a superelevation of 6 in. That portion of the subway and incline west of Charlesgate East is, on account of the depth of silt in the Fens, supported on piles from 25 to 35 ft. long. The remainder of this section rests directly on the clay and sand or on footings of concrete carried down below the subway walls to those materials.

Drainage and ventilation equipment will be accommodated in a combined pump well and fan chamber situated in the Fens near Charlesgate East, midway between the incline and the station at Massachusetts Avenue. The pump wall has a sump 11x17 ft., and 11½ ft. deep, with a capacity of about 2000 cu. ft. below the invert drains. The pumps will be installed just above the track level, and will discharge into the Stony Brook conduit. The fan chamber is placed on the subway roof adjoining the pump well, the fans to exhaust the air through holes in the floor of the chamber and discharge it through a chimney inclosed in a building which will also cover an emergency stairway.

In this portion of the subway are found the most unfavorable conditions of alignment and grade met on the whole project, and here also some of the greatest diffi-



Typical Cross-Sections of Subway with and without Center Walls culties of construction have been encountered. Two curves in opposite directions, each having a radius of 400 ft., were required, and, although they have transitions and are separated by a tangent 100 ft. long, constitute the sharpest curvature on the subway. Heavy grades also had to be used, as shown, to carry the structure beneath the Fens Pond and the Stony Brook conduit. The depth of the subway has led to especial difficulties in supporting the ground and the buildings along its route, and the fact that it is entirely submerged beneath the water in the Fens Pond and in the adjacent earth has greatly added to the difficulties of efficient waterproofing. In spite of these difficulties the buildings have been safely sustained without underpinning, and the leakage of water into the subway is slight.

MASSACHUSETTS AVENUE STATION

The most westerly station, 350 ft. long and 90 ft. wide at its widest part, extends from Massachusetts Avenue through private property, across a public alley and into a storage yard taken from the Public Works Department. Beyond the station the subway, still retaining its center wall, swings to the north on a compound curve having radii of 500, 979 and 1459 ft. through the basement of the police and fire department buildings into Boylston Street at Hereford Street.

Although it is well below the surface of Massachusetts Avenue, the subway structure stands out about 12 ft. above the surface of the alley and yard and occupies practically the entire height of parts of the basements of five private stables fronting on Newbury Street, and of smaller portions of the basements of the police and fire department buildings. A one-story stable was entirely demolished and replaced by a new stable and garage over and around the completed subway. Another building, a large stable at the corner of Massachusetts Avenue and Newbury Street, where are now situated the station entrances and exits, was purchased and razed before constructing the subway. The construction of the portion of the structure through the remaining buildings without disturbing their upper stories required tedious and careful work, the underpinning difficulties of which have been complicated by the necessity for pile foundations and footings 10 ft. deep below the side walls and columns of the subway.

PLATFORMS AND STAIRWAYS

The station consists of two straight and level opposite platforms, the tracks separated by a center wall. Both platforms are wide at the entrance stairways and tapering toward the ends. The areas of the outbound and inbound platforms are respectively 6650 and 6500 sq. ft., the increased width of the former at the foot of the main stairway being provided on account of the expected movement of passengers up and down the platform to board particular cars whose exact stopping point cannot be pre-determined. Through each platform, 8 ft. from the edge, extends a line of heavy columns which, with the center wall, are designed to support not only the subway roof, but also future heavy buildings over the roof. The floor is at the level of the rail, 14.75 ft. below the roof, giving a spacious effect not always obtained in subway stations.

Wide stairways from each platform lead to a superimposed mezzanine ticket office lobby situated in the rear of the property at the corner of Massachusetts Avenue and Newbury Street, from which a 16-ft. covered passage and stairs for entrance and exit lead to Massachusetts Avenue, where there is a waiting room 34 x 16 ft. at the street. An additional 8-ft. stairway and ramp rise to Newbury Street from the ticket-office lobby. In addition to these means of access to the station, provision is made for entrance and exit at its easterly end by means of an 8-ft. ramp and stairway from each platform leading to the roof in the Public Works Department yard, where a walk over the subway will lead into Boylston Street.

HEREFORD TO DARTMOUTH STREET

From Hereford Street east the center wall is omitted. The structure throughout this section is entirely of reinforced concrete, the inside section being formed of the usual curved side walls, supporting a flat roof 30 in. thick under the waterproofing. In order to effect an equal distribution of the supporting power of the earth, the invert is, as shown, 36 in. thick at the middle below the drain. For a short portion of its upper length where the invert is in the silt or peat, footings of concrete 4 ft. wide have been carried down to the sand stratum for additional support.

At Fairfield Street, about half way between stations, there is a chamber for fans which will exhaust the vitiated air through openings in the side wall and discharge it to the surface through a sidewalk grating. In connection with this chamber is a 4-ft. stairway to the sidewalk for employees and for emergency use.

COPLEY SQUARE STATION

At the westerly end of the Boston Public Library, 2500 ft. from the first station, the inbound platform of the station at Copley Square begins. This platform is 350 ft. long and 20 ft. wide. It is connected with the street at about its middle point from a small ticket-office lobby at the rail level, through an 8½-ft. and an 8-ft. stairway, uniting at a landing into a stairway 15½ ft. wide, and thence emerging to the surface at right angles to Boylston Street under an iron and glass covering, harmonizing with the library building, against which it is placed. At the westerly end of this platform a straight flight of stairs 5 ft. wide for exit purposes leads to the Boylston Street sidewalk at the curb. A chamber for pumps is situated below these stairs; its sump is 16x16 ft. and 8.5 ft. deep below the floor, and has a capacity of 1350 cu. ft. below the bottom of the subway drain.

Opposite the middle of this platform, and separated from it by the tracks and by center columns, is the beginning of the out-bound platform, also 350 ft. long and 20 ft. wide. A long lobby under Dartmouth Street with 8-ft. stairways to both of the wide sidewalks of that street affords entrance and egress to this platform. The platforms of this station, exclusive of the lobbies, have areas of 7000 sq. ft. each, and like those at Massachusetts Avenue are both straight and level. Throughout the length of the station the roof is supported by rows of columns 12 ft. center to center, set 8 ft. back of the edge of the platforms, and by another row of columns between tracks set 6 ft. on centers. These columns support continuous, heavy, longitudinal girder beams buried in the roof, and are in turn supported by steel grillages 3 ft. long, set in the invert. The floor is at the level of the top of rail, but in order to provide space in the street for pipes and conduits, the vertical clearance, which is 15 ft. over the tracks, is reduced between the platform columns and the platform wall to 12 ft.

FLOATING SECTION OF STATION

On account of the presence of the leaning tower of the Old South Church, which is situated directly opposite the subway entrance at the public library, it has been thought wise to omit foundations of any character below the bottom of the station west of Dartmouth Street, to inclose the structure within lines of steel sheet piling at this point, and to float it on the silt. On this account the invert is made extremely heavy and to allow for a possible settlement of the structure at this point the overhead clearance through this portion of the station has been increased 3 in. The construction of this station has been made without injury to the church tower, and so far no local settlement or cracking of the walls has developed in the subway on account of the lack of a pile foundation. From Copley Square to Arlington Street the subway is deep in the ground in consequence of the necessity for passing under the 6 ft. sewer at Berkeley Street, the bottom of which is 14 ft. below the surface. On account of the heavy cover of earth, a center support to the flat roof has been provided, this time in the shape of steel columns set 6 ft. on centers between tracks and supporting a longitudinal steel girder buried in concrete, as in the Copley Square station. Between Berkeley and Arlington Streets, in order to provide clearance for cars at a proposed crossover, this center line of columns has been omitted for 152 ft., and a semicircular reinforced-concrete arch of 29.7 ft. span substituted for the flat roof.

From Dartmouth Street for about 400 ft. easterly the subway structure is supported by piles; for the next 300 ft. it is supported on longitudinal footings of concrete below the center columns and side-walls extending through the silt to the clay below. The remainder of the subway to Arlington Street rests directly on the hard clay.

At Berkeley Street, on the north side of the subway, at the level of the track, is situated the third and last chamber for fans, from which the air is to be discharged through a grating in the Berkeley Street sidewalk by the side of a 4-ft. inclosed stairway leading from the subway alongside the air duct.

PARK SQUARE JUNCTION

At Arlington Street the tracks begin to diverge, and at Church Street the surface tracks descend between them through the new incline to a stretch of four-track subway, 65 ft. wide, in which surface and subway cars proceeding in the same direction run side by side. The north wall of this section of the four-track subway crosses the existing Tremont Street subway at Park Square, thus the old incline in the Public Garden is cut off, and is to be abandoned and filled up. The new incline will be nearly in the middle of Boylston Street, which is to be widened for this purpose by taking from the Public Garden between Arlington and Charles Streets a strip of land slightly greater in area than that which is to be returned to the Public Garden by the abandonment of the present incline. At the junction of the two subways in Park Square the temporary connection between the tracks of each is to be made. At this point also, in the future, when the two inbound tracks are extended in a new structure, and the outbound tracks are carried in the old structure, switching between the surface and subway systems can be easily accomplished without crossings at grade.

The widening space of the roof from Arlington Street is supported first by the standard steel-column and longitudinal-girder construction and then by two concrete walls. Beneath the incline the structure divides into two barrels of reinforced concrete, which, just beyond the portal, merge into the four track subway, whose section consists of the usual side-walls, a center row of columns and a level roof of transverse concrete jack arches, supported by 26 in. Bethlehem girders. As the greater part of this four-track subway is through a pocket of peat, in some places 28 ft. thick, it is supported on a pile foundation.

PERSONNEL

As previously stated, the subways under construction are being built by the Boston Transit Commission, of which Professor George F. Swain is chairman, and Mr. Edmund S. Davis, chief engineer. The Boylston Street division of this work has been under the direction of the writer, who has been assisted in the field by three section engineers—Messrs. James B. Flaws, F. I. Garfield and James T. Frame. The structural details of this work in common with that of other subway work under construction has been designed or passed upon by the structural division of the engineering force, under the direction of Mr. George H. Stearns.

The contractor for all of the work has been the Hugh Nawn Contracting Company, of which Mr. Harry P. Nawn is president. To Mr. Nawn's aggressive personality and the efficient organization of his force is due to a marked extent the rapid progress of the construction.

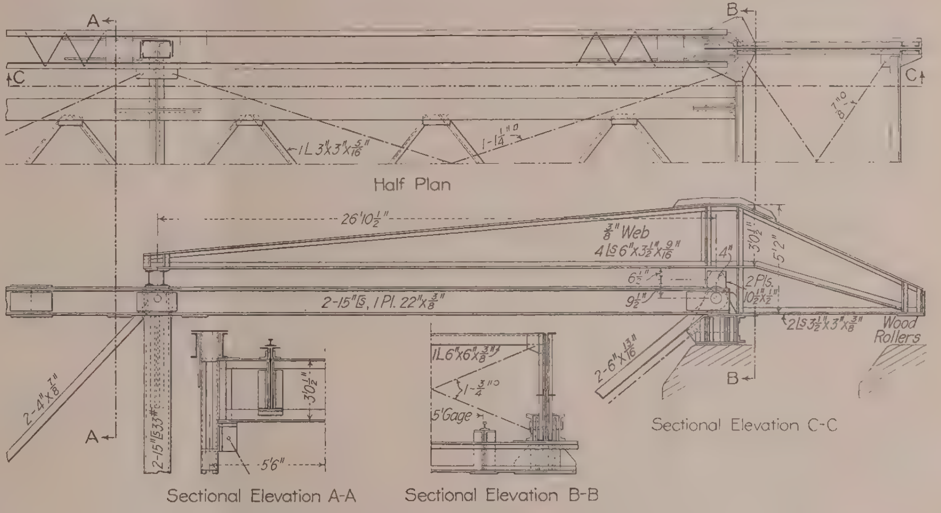
The contract for the last section calls for the completion of the connection with the Tremont Street subway by May 1, 1914, and it is expected that the remainder of the subway will be completed and equipped by that time. On a Saturday night the last car will run through the Public Garden incline, and the tracks will at once be removed in the Tremont Street subway at Charles Street. Then new columns to support the roof will be placed on the abandoned roadbed, the remaining posts separating the old subway from the new will be removed, the tracks in the new subway will be connected with those in the old, and on the following Monday morning the Boylston Street subway will be in use.

FIREPROOF WOODEN SHINGLES are being made in the forest products laboratory of the University of Wisconsin at a cost of $15 per thousand. The method consists in forcing into the wood, under pressure, such chemicals as ammonia sulphate and ammonia phosphate.

Erection of the Panama Lock Gates

Second Article Dealing with the Handling of Large Members and Methods of Executing Work of Great Precision on Lofty, Massive Structures

CONSTRUCTION at a remote site in the field of forty-six of the largest steel lock gates ever built has been accomplished at Panama by special methods and plant, the general features of which were described in the Engineering Record of Nov. 8, 1913, page 513. The hollow leaves, from 47 to 82 ft. high, have a maximum weight of 730 tons each and have a framework of horizontal girders 65 ft. long and 7 ft. deep, weighing as much as 18 tons each. These were shipped complete from the shop and were assembled at the site in successive tiers from the bottom to the top of the structure. They are covered with flat and curved steel plates riveted to the girder flanges and to vertical frames to form numerous watertight and airtight chambers, and are fitted to have perfect bearings in the long vertical joints against the sides of the lock and between adjacent leaves.



Plan and Sectional Elevations of Cantilever Extension for Erection Bridge

Falsework towers, travelers and fixed tackles were eliminated for erection work and for assembling the tall structures on their extremely narrow bases, which afforded a very small moment of stability. The erection was done by means of traveling cranes, with long booms operating on very high overhead bridges, and thus lowering instead of raising the material. These features and the shipping, storing and handling of heavy members, fitting, reaming and riveting the plates and testing the tightness of the work involved points not dealt with in the article previously referred to.

All of the material, amounting to about 57,552 tons, and including 1540 main girders, was fabricated at the contractor's shops near Pittsburgh. The heaviest pieces were the horizontal bottom girders reinforced by 15-in. I-beam stiffeners and weighing 18 tons each. Nearly all of the material was delivered to ships at Baltimore and carried by them to Cristobal, where it was unloaded by the ships' tackle and delivered to cars on the single-track railroad, by which it was transported to Gatun, Pedro Miguel and Miraflores.

Both leaves of each gate were erected simultaneously in temporary positions arranged to give suitable space for working around them. They were located 4 ft. from their permanent bearings, to give working clearance around the quoin ends, and the miter ends were set so as to leave a distance of 12 ft. between them to permit the passage of concrete cars through the locks. The leaves were erected 7½ in. higher than their required elevation, thus making it possible to move the pintle socket over the pintle bearing and affording an opportunity for calking or other work to be done on the bottoms of the leaves. After erection the leaves were moved horizontally on rollers and lowered by screw wedges to their permanent center bearings, as described in the previous article.

The steelwork was loaded on flat cars in the storage yard, run on to the erection bridges and lowered to position by two Industrial and two Browning 50-ton locomotive cranes with 65-ft. boom and a capacity of 18 tons of 36-ft. radius, the maximum distance at which it was necessary to handle their loads.

Generally the heel and pintle castings and all of the vertical frames—which had a total weight of about 26 tons—were riveted to the bottom girders in the storage yards and lowered to place by two cranes acting together. The girders were very accurately leveled on seven pairs of 15-in. I-beam sills and all of the vertical frames and the remainder of the girders, except the top girders, were erected and all interior rivets—that is, rivets through the webs and stiffeners of the girders—were driven. After the framework was riveted the bent plates and side sheathing were attached by service bolts through every other hole, and the top girders erected.

After the scaffolds and hangers for the large reaming machines were erected, extension girders were bolted to the top chords of the erection bridges to enable them to span the gate recesses, the bridges were moved forward to positions for the erection of the next set of leaves, and so on. Usually the lower pintle casting, the pintle, the heavy reaction castings and the yoke and jaws of each leaf were stored at a convenient point on top of the bank, ready for erection after all structural steelwork was assembled and riveted.

All of the steelwork was laid out in the shops by the use of steel templates, which in every case were pieces actually used in the structure, on which the holes were carefully measured and marked in the shops and then checked by a draftsman, thus making full-size drawings on the steel itself. The holes connecting the sheathing plates to the skeletons were drilled or punched 11/16 in. in diameter for ⅞ and 1-in. rivets and reamed full size in the field. The corresponding holes in the girders and skeletons were previously reamed to steel templates in the shop, according to the plan carefully discussed before fabrication was commenced.

Fifty-five thousand holes were reamed in each of the largest leaves, the work being done in the field. Most of them were reamed by sixteen electric machines built by the Foote-Burt Company, of Cleveland, and operated by 10-hp Westinghouse motors. Each machine ran on a horizontal track extending the full length of the leaf on a vertically adjustable scaffold suspended by Yale & Towne duplex chain blocks, by which the scaffolds were raised one story at a time. The machines, operated by one man each, reamed from 300 to 600 holes in one eight-hour day.

A small percentage of the holes, including those at the ends of the leaves through the top and bottom girder flanges, and part of those through the curved portion of the upstream sheathing plates, were reamed with Vandorn & Dutton electric drills. As the erecting progressed the interior holes were reamed with hand tools made by the Independent Pneumatic Tool Company. The 1 3/16-in. and the 1 13/16-in. holes for the end-reaction castings were reamed with larger drills made by the last-named company and with Little Giant drills made by the Chicago Pneumatic Tool Company.

RIVETING

The driving of the 5,750,000 field rivets—enough to occupy every working day for two years if 10,000 rivets were driven daily—was a very serious item of the erection, requiring special attention and urgent efforts to organize and direct the operation so as to secure the necessary progress. Except for a few ¾-in. interior rivets and some 1⅞-in. rivets through the end-reaction castings, nearly all of the field rivets were ⅞ in. and 1 in. in diameter, the number in each leaf varying according to the height of the latter. Each 77-ft. leaf had approximately 16,000 rivets driven in the erection of the skeleton work and 46,000 sheathing rivets, making a total of 122,000 field rivets for the completed gate. All of the rivets were driven with No. 90 Boyer hammers.

The calked edges of all skin plates more than ½ in. thick were planed square; those of thinner plates were planed at an angle of 45 deg., thus securing satisfactory results on all thicknesses of plates. The lower part of the leaf forms an airtight chamber, subdivided by three watertight vertical bulkheads; the remainder of the leaf is watertight. All calking was done with Chicago pneumatic tools, the joints between the watertight frames and the girder webs being calked before the sheathing was put on and the main exterior calking being done after the leaves were hung on their pintles.

After the countersunk rivets were driven in the vertical end plates and calking was completed the surface was prepared to receive the end-reaction castings by grinding all high spots until the surface was true under a 5-ft. steel straightedge. This work was done by No. 7 Independent spur grinders.

BRACING AND MOVING

It was at first intended to brace the leaves for lateral stability during erection by means of the tower frames used for moving and lowering them, but as this was found to interfere with the attachment of the sheathing and with the field riveting the frames were omitted until after the leaves were erected and riveted. Each frame consisted of a 10-ft. 7-in. x 5-ft. x 54-ft. high tower, with two main columns proportioned to carry the whole weight of the leaf. The columns were bolted to the face of the leaf at each girder connection. Towers were provided for eight leaves on the Atlantic division and eight leaves on the Pacific division of the canal.

Each main column was proportioned for a maximum load of about 200 tons, including the weight of scaffolds, machines and men. Its base rested on a pedestal raised or lowered by a pair of wedges adjusted and locked by a horizontal right and left-hand screw, an apparatus devised by Mr. Wilbur J. Rockland, of Cleveland, Ohio, and was used for striking the centers of the Rocky River concrete arch bridge. It was later used by Mr. L. L. Jewell for 200-ton camber loads for the Missouri River Bridge at Kansas City, and adapted by him for the lock gates.

VERTICAL BEARING

The axis of the lock chambers lies in a line so nearly north and south that the lower parts of the gate leaves were subject to scarcely any exposure to the direct sunshine, while the upper parts were exposed to it nearly all day. In consequence they were subjected to a wave-like distortion, starting at the top in the early morning and passing lower and lower down the end of the leaf as the day advanced. On this account the bearing leaves were brought to contact at or before daylight and adjustment made as described in the previous article.

After the adjustment was made it was checked by closing the gates in the very early morning and obtaining satisfactory contact before the plates were finally babbitted in permanent position. The accuracy of this method depended on the assumption that the change in the length of the leaf due to temperature variations was uniform from top to bottom, an assumption in which the error was considered to be negligible. Both the quoin and the miter ends of the upper guard gates at this end were found to be watertight under only about 10 ft. of pressure head.

The specifications require that the entire air chamber, the vertical frames subdividing it, the pump chamber, the manshaft, the downstream sheathing above the air chamber and the connections of the end-reaction castings to the leaf and to each other must be watertight when the leaf is under the maximum head of water that will come upon it in actual operation. This test consisted, in each case, in filling the air chambers with water from the manshaft to the top of the gate.

After all of the riveting and end work on the leaves were completed the leaves were blocked up for continuous support on the bottom, and were completely filled with water, which eventually was successively drawn off from different compartments of the air chambers, subjecting them to unbalanced pressures. The four applications of these tests developed very few leaks, which were quickly and easily stopped.

The deflections of the extremities on several of the leaves when they were swung open were measured and the maximum was 3/16 in. In nearly all cases after the leaves had been hung and the center pins and bearings had been blocked to exact bearing the leaves were jacked up to relieve the stress on the yoke, and the adjustment wedges of the latter were again driven as tight as possible.

ERECTION BRIDGES

For temporary spanning the lock chambers and supporting the erection-locomotive cranes there were at first provided four movable bridges, each having a pair of pin-connected deck trusses 115 ft. 6 in. long, 22 ft. deep and 11 ft. apart on centers. Afterward four more bridges were installed to expedite the completion of the work.

The train-track rails were carried directly on the top flanges of the stringers. The top chords received at panel points the blocking for the outriggers for the cranes in service. Each truss was designed to carry the entire crane load when the boom was swung, so that the latter was balanced on the outriggers. The trusses were designed for unit stresses of 16,000 lb. in tension and 16,000 lb. reduced for compression.

Each complete span weighed about 85 tons, and was arranged for an extension of 9½ ft. at each end to enable it to span the increased width of the gate recesses when moved along the lock chambers. The extensions were secured by connecting the cantilever girders to the end panel of the top chords by means of vertical tension plates engaging the end top chord pins and reaction I-beam bearings over the vertical posts at the first panel points. The cantilever ends of the girders were connected by a horizontal strut and by X-brace rods.

POWER

On each division there was installed a power plant equipped with two Ingersoll-Rand and two Laidlaw-Dunn-Gordon duplex air compressors, each with a capacity of 550 cu. ft. of free air per minute. All of them were belted to 100-hp General Electric motors supplied with 220 volts alternating current furnished by the canal commission. Air was delivered, at a pressure of 100 lb., through service mains running from the power house the full lengths of the sets of locks. A 50-kw motor generator operated by the 2200-volt current furnished 220 volts direct current for the electric reamers, inside lights, and for other purposes. All of the locomotive cranes were equipped with separate steam boilers burning coal.

The gates were constructed under the direction of Col. George W. Goethals, chief engineer, Isthmian Canal Commission, and were designed by Mr. Henry Goldmark, designing engineer. The contract for fabrication and erection was awarded to the McClintic-Marshall Construction Company, of which Mr. Paul L. Wolfel is chief engineer and Mr. W. M. Sterrett manager at the site in charge of erection, which was commenced by Mr. L. L. Jewell, formerly engineer of erection for the contractors.

Purchasing City Supplies

First Portion of Report by Elihu C. Church on Scope and Duties of Supply Bureau, Department of Water Supply, Gas and Electricity, New York City

INEFFICIENCY, lack of co-ordination and demoralization are terms which have been used to characterize the operation of the Bureau of Supplies of New York City's Department of Water Supply, Gas and Electricity two years ago. To-day the bureau's functional organization is spoken of as a model of its kind and its activities are said to have been so systematized, its methods so standardized and its employees so trained that the present operation is well-nigh automatic. How this result was accomplished is told in a report submitted on Nov. 24, 1913, to Commissioner Henry M. Thompson by Mr. Elihu Cunningham Church, secretary of the department and chief of the Bureau of Supplies. The substance of the first chapter of the report, dealing with the scope and duties of the bureau, is given below.

When first formed, the Supply Bureau of the Department of Water Supply, Gas and Electricity was really a mere purchasing division doing a sort of commission house business, with no voice concerning the maintenance of stock, the quantity or quality of supplies bought, their inspection, storage, issue or accounting. Realizing that this was wrong because it violated many fundamental rules of business management, an endeavor has been made to formulate the basic principles involved and then proceed accordingly.

It is assumed that the department has or should have a definite program regarding all new work, improvements, standards of maintenance, and standards of operation, which will absolutely govern all its actions. The establishment of such a program is a "staff" problem that should be developed and formulated by experts. It is based on the conditions to be met, the work to be done, and the funds available; and, having been adopted, it should shape the activities of the department for years to come. An absolute change in expected conditions, or unforeseen emergencies, are the only things that should effect any alteration in such a prearranged plan, for a carefully considered policy of this sort gives stability to a department and enables all work undertaken in accordance with its terms to be done under the most favorable conditions.

Such foresightedness on the part of all would lead to co-operation and team play between the different departments, and do away with present conditions under which one branch of the city's government puts down a pavement and another straightway comes along and rips it up to build a sewer or lay a water pipe.

LINE AND STAFF DUTIES

The preparation of the contracts necessary to carry out this "policy," and the purchase of the required supplies are "line" duties. The scope of these duties is fixed by the "staff" policy, for no official would prepare a contract for which there were no funds provided, and no one would be permitted to veto a requisition for supplies when it was understood that it had been prepared in strict accordance with established standards and was for quantities which long study had shown to be absolutely necessary.

The sum total of Supply Bureau efficiency is ordinarily assumed to have been secured when (1) the bureau itself is run economically, (2) the most reasonable prices are obtained for all articles purchased, (3) the articles called for and paid for are the ones delivered.

FUNDAMENTAL PRECEPTS

All supplies ordered and bought should be really necessary. There may be a great many reasons why proposed expenditure is not necessary. Perhaps there is a great surplus of identical stock in some storeroom which is available, yet not used because there is no inventory to show its existence, or no system of stores control to ascertain the fact before going into the market for more. It is for this reason that the Bureau of Supplies should have charge of all goods in storage, that it should be responsible for the inventory and that it should maintain a system of stores control.

All supplies specified and bought should be those best suited to the use to which they are to be put. It frequently happens that large sums are wasted by calling for materials far too expensive and of too high a grade for the purpose intended. Again, it sometimes happens that poor material is bought because it is cheap, whereas a better and more costly article would have rendered proportionately far more service. To obviate this, the Bureau of Supplies has set up standards and written specifications so that the most suitable supplies may be bought and the same article used for the same purpose throughout the entire department.

The precise quantity needed should be ordered. When a man leads a hand-to-mouth existence, continually ordering small quantities of material, he puts the purchasing division to a lot of expense, as it costs nearly twice as much to handle a small order as a large one. The cost of delivery is away out of proportion to the size of the shipment and the necessity for inspecting each lot increases inspection costs. On the other hand, when told to do a piece of work most men "get on the safe side" and order far more material than close figuring would show to be necessary. This is particularly true where the machinery of purchasing is cumbersome. A man hates the bother of making out another order for additional stock. If more material has to be purchased and there is much red tape he may have to wait a long time and the job will be delayed. Quantities should be checked and men held responsible for extravagant requisitions. Before the Bureau of Supplies was created it had often happened that great over-stocks were purchased because the individual ordering did not understand conditions. Interest on investment, depreciation and other losses made this an expensive way to do business.

Purchases should be made in accordance with a definite plan and under most favorable market conditions. It frequently happens that a half dozen requisitions to purchase some standard material are sent in one at a time during the course of the year as the various projects develop on which the material is wanted. Ordering supplies in this manner is unsatisfactory. It greatly increases the office expense for purchasing, it prevents the combination of similar requisitions in order to obtain wholesale prices, and the fact that immediate delivery is generally demanded makes it impossible to wait for favorable markets before buying.

One improvement is that a large proportion of the supplies now bought are ordered in advance and instead of being delivered direct to the consumer are consigned to the nearest storehouse, where they are inspected and stored and later delivered from stock as called for on requisition. In this case the stores act as distributing depots.

If the Bureau of Supplies could stop doing business on a "commission-house basis," much further good would result. The chief of the bureau should be consulted in conference by the other bureaus—and should be thoroughly informed concerning all proposed undertakings—a policy which has been strongly advocated. He would no longer wait till notified of the immediate need of materials before purchasing them, but would anticipate the future requirements of the department and prepare a material budget to supply them. It would then be the duty of the Bureau of Supplies to keep in its storerooms a stock of various standard goods which it could issue immediately on requisition. The storerooms would then fulfil their proper function by being real collection or storage depots.

FIXING LIMITS OF STOCK

The amount of money invested in material should be kept at a minimum. Fixing the limits of stock to be carried is most important. In order to know the proper amount of stock to keep on hand, the chief of the bureau should be in close touch with the work of the department as a whole, and with the details of that "program," before referred to, which is supposed to regulate all activities. He should know of all new work and all contemplated improvements a sufficient time in advance to purchase the required supplies in a favorable market, and to have them delivered, inspected and ready when needed. He should be informed concerning the amount and nature of materials necessary to be kept in reserve at certain points for various emergencies. He should be fully posted regarding the stores required for current operating purposes, and any changes in "policy" which will affect the same. Using these facts in connection with the data on the time required to obtain or replenish stock by purchase or transfer makes it easy to calculate the minimum quantities of stock to be kept in storage.

The question of the proper amounts of emergency equipment, spare parts, tools, implements and current supplies to be maintained by the operating divisions is most important, though apparently it has not yet been standardized.

Materials should be properly stored and issued. It has always been considered a grave error in organization to place the control of materials and supplies, in large quantities, in the hands of the men who use them. The bureau has insisted that it should store all materials and supplies prior to issue, under the care of responsible men especially detailed to that work. With this end in view, it has always assumed charge of storage points whenever permitted to do so. The economy in consumption and diminution of waste effected by this control has been remarkable. The previous improper methods of storage and accounting for supplies have become apparent as the various storage points have been placed under the jurisdiction of the bureau. Rules for the care and storage of supplies after issue from stores and while in the hands of the ultimate consumers should be prepared and enforced.

Supplies should be put only to the use intended. This is a matter only partially within the control of the bureau. Purchasing agents can assure themselves that goods bought are suitable for the requirements, and storekeepers can report when goods requisitioned out of stores are not suited to the ostensible use to which they are to be put, as stated on the order. They can also prevent deterioration in stock and loss from theft, which certainly do not come under the head of "use intended." Beyond that they cannot go, though branding and marking stock is perhaps a further safeguard. There should be inspectors, operating along the lines of the Inspector-General's Department of the regular army, whose duty it should be to investigate and see that stores once issued are put to the proper use.

Supplies should be used efficiently and economically. No matter how careful and saving the bureau may be in the matter of purchase, inspection, storage and issue of supplies, if the men using the material use it inefficiently or wastefully it will soon give out and have to be replaced, with the result that the cost of supplies to the department, and thus to the taxpayer, will be high. Again we have a condition beyond the jurisdiction of the Bureau of Supplies as now organized, yet vitally affecting the amount of supplies which have to be bought.

Supplies should be kept in service till they are worn out, or changed conditions require the substitution of a more efficient or more economical article. Loss is often incurred by premature replacement of materials. To the cost of the new article must be added the cost of the replacement plus the remaining value of the article replaced, which can seldom be used elsewhere.

REMOVING UNNECESSARY RESTRICTIONS

All useless, burdensome and foolish restrictions and conditions should be removed from the bidding requirements and the specifications. The city's business should be made as attractive to possible bidders as is that of any of the great private corporations. On the contrary, doing business with the city is now fraught with many needless annoyances and restrictions. Many of the conditions so imposed cause the contractor actual expense, while others merely introduce elements of uncertainty and possible loss against which he must protect himself by increasing his bid proportionately. All such restrictions, whether actual or potential, are ever present handicaps to proper economy.

Some of these conditions are imposed by law; others are the result of bad purchasing methods, improperly worded specifications, inefficient office procedure or conduct of employees. It is foolish to imagine that the lowest possible prices have been obtained merely because the letting was public, bids being taken, and the award made to the lowest bidder; for many may not have bid who otherwise would have been glad to put in a price, and others who did bid might have bid lower.

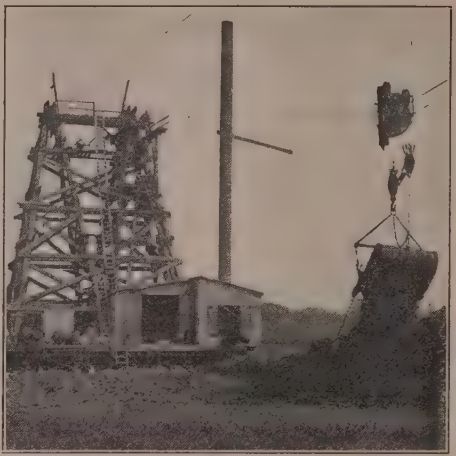
The disposition to be made of excess stores or equipment and obsolete or damaged material constitutes the one remaining point where the activities of the Bureau of Supplies are so closely related to those of other branches of the department that friction has often resulted. This work can best be done by a board of survey, consisting of an official of the bureau and a "staff" engineer. They should periodically inspect and survey all stores, equipment, engine spare parts or other supplies owned by the department for the purpose of (1) condemning and ordering to be sold all (a) obsolete material and (b) damaged material not fit to be repaired and (2) ascertaining whether such material as may be damaged or worn is worth repairing, and, if worth repairing, directing that said work be done.

Double Dragline Cableway Excavator for Canal Work

Use of Self-Contained Duplex Outfit for Dry Prism Excavation on New York State Barge Canal

A DOUBLE dragline cableway excavator is doing highly satisfactory work in excavating the prism for the New York State Barge Canal. The machine is being used on practically level ground where there is not enough water available to float a dredge and where the approximate balancing of quantities in the finished canal is being accomplished by spoiling the material on either side of the cut. The work is handled and the entire range is covered by two dragline excavators working in opposite directions on two independent cableways spanning 500 ft., carried by a duplex tower on either side of the canal. Each tower carries the operating machinery for one cableway.

Each excavator has a capacity of 3 yd. It is filled by direct pull, using 1¼-in. wire rope led direct from a drum mounted in front of and geared to the regular type of cableway engine. The rope passes from the drum up to an elevated sheave in the tower, whence it leads direct to the front of the scraper. Here it is attached by a bridle connection so that when the scraper is lowered into place a direct pull is obtained in filling the scraper. When filled, the hoisting and dumping lines are wound in raising the bucket, which is then transported at high speed to the spoil bank.


Skip and Self-Propelling Tower

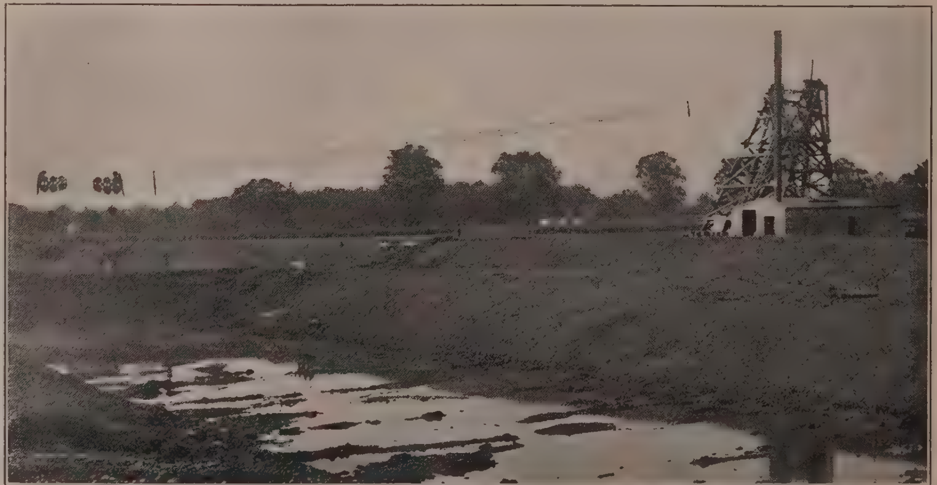
Change gearing is fitted to the main dragline drum so that in filling the scraper a heavy pull at reduced speed is obtained, after which the operator shifts a clutch to increase the speed of the dragline to equal that of the hoisting, dumping and conveying ropes. Thus as the bucket is raised or conveyed in either direction the speed of all of the lines becomes uniform and each part does its share in hauling the load.

Dumping is effected rapidly by the use of the Locher improved steam piston pump. This operates by pulling down a loop in the dump rope, thus raising the back end of the skip and allowing the material to slide out. The piston is then released, the dump block settles and the skip goes back to its normal position.

The towers are each mounted on five-rail tracks, and are self-propelling. The track is carried forward piece by piece on a series of power-driven rollers on the underframe of the platform.

This machine has a monthly output of from 58,000 to 62,000 cu. yd., working two shifts of eight hours each. In five months 304,588 cu. yd. were handled. The outfit advances about 80 ft. per day. One man is required to signal at each excavator; one man on each dump supervises the unloading; two men are required at the operating plant in each tower, and eight men look after the track work. One of the illustrations shows how cleanly the excavators do their work. No additional work is required in the bottom of the prism, and only a small amount of hand labor is necessary in dressing up the slopes. The material is variegated—muck, clay and gravel of various degrees of coarseness.

The machine originated with Mr. Charles H. Locher, of the firm of Grant Smith & Company & Locher, of New York City, who are associated with the M. A. Talbott Company, of Baltimore, on the general contract. The piston dump and other features of the system are patented. The cableways are of the Lidgerwood make.


General View of Cableways, Duplex Tower and Finished Canal Prism

Problems of the Contractor

Second Portion of Abstract of Address by Leonard C. Wason on Organizing and Executing Construction of Reinforced-Concrete Industrial Building

THE first part of this paper by the president of the Aberthaw Construction Company published by the Association of Engineering Societies and reprinted in the Engineering Record of Dec. 20, page 693, dealt with the personal factor in developing a construction organization and with the preliminary mechanical steps. The second part traces the execution of the contract through assembling the materials, laying out the construction plant, handling forms and reinforcement, and protecting the work from the weather, all carried out in accordance with an up-to-date system of planning, routing and cost accounting.

PURCHASE OF MATERIALS

The contractor is very largely a broker buying materials to be incorporated in a building. Some materials are easy to buy and some require a detailed knowledge of the materials themselves and also of the estimate and contract and the relation of one class of material to another. Therefore there is a distinction made between routine buying and experienced buying. Of the routine buying, some can best be done locally from the job and some from the main office of the company. There has been compiled a complete list of all materials which enter into a job, and then it is decided which of the routine items can most advantageously be bought by the main office and which by the job superintendent, and written instructions are prepared for these items.

Lumber and steel schedules are generally the first to demand attention. Lumber used in contact with cement is almost always ordered planed four sides. A correct ordering schedule for lumber cannot be made, of course, until the work of detailing forms is nearly completed in the drafting room. It is possible, however, to make an approximate schedule for canvassing for prices. By referring to standards we are generally able to tell in advance what sizes are wanted, and are ready to order material forward as soon as centering details are completed. As lumber arrives the material of different dimensions, qualities and finishes is piled by a prearranged plan worked out in the office handy to the woodworking shop and given numbers or letters obtained from the key plan.

The steel is taken off the plans by one man and checked independently by another. This schedule is then studied in regard to reducing the variety of lengths, and frequently these can be reduced to one-fifth of the number shown on plan. It is usual to order a schedule of bars ¾ in. and larger in multiples of 6 in. and to buy steel ⅝ in. and under in the longest lengths that can be put on a single flat car, and cut it up on the job. The largest sizes recommended are 1¼ in. square and 1⅜ in. round; the smallest ¼ in., all sizes to be multiples of ⅛ in. On one large job there were over 400 different lengths of bars shown on plans, and by scheduling large bars in multiples of 6 in. and ordering small bars in long lengths, as above described, the mill order was reduced to 46 different lengths. This method only increased the weight of the order so as to cost $18 in excess of the exact schedule taken from the plans, a sum saved many times over in the greater convenience of sorting and handling the steel. The manufacturers are required to deliver the small bars in bundles weighing from 125 to 145 lb.; this insures the men getting a load of proper weight for greatest efficiency.

A study of comparative costs on different buildings indicates that about 35 per cent of the money spent is for labor, over one-third of which is consumed in the making up, erection and stripping of forms. This, combined with the fact that lumber and labor are continually advancing in price, would indicate that a very careful study devoted to reaching the greatest simplicity and regularity in making up panels, and of using the lumber with the most efficiency, is a vital factor in low cost work. By "panel" is meant several boards cleated together so as to be handled as one piece. To gain this efficiency the study of the forms should not be left to carpenters, but it should be the sole work of a corps of men trained to think forms all the time.

THE PLANT

Study of the amount and location of mechanical plant has to be made immediately after the contract is awarded if work is to be started promptly, as part of it is put into operation with the very beginning of construction. As a good deal depends upon the amount, design and promptness of delivery, so far as economical construction goes, the best thought of the whole organization is put on the subject. For instance, one of the younger men made a study for a large job on the basis of a story a week. To obtain this rate one mixer and two stories of forms more were required than if the progress was slowed down to a story in nine working days. Such speed was not demanded. A conference of all hands corrected the first study, making an estimated saving in job cost of about $10,000.

The method of distribution of concrete through the building requires some consideration. If a building is compact and large masses are placed within a limited area, spouting is desirable. If the building is spread out and quite small quantities of concrete used, two-wheeled pushcarts are used, while if large quantities are required over quite an area, industrial tracks laid on horses so as to elevate them about 18 in. above the forms are run over the latter to distribute concrete a batch at a time.

After the job superintendent is determined upon, he is taken into consultation for every step which follows. The selection of all his subordinates is made in co-operation with him—assistant superintendent, clerical force, carpenter, labor, concrete, steel and other bosses; the principal mechanics and even the leading laborers are all selected in advance from among those working on other jobs. The superintendent, where possible, is given at least a week to study plans and specifications in co-operation with his principal assistants and the office force, before anybody appears at the site of the work except for the mere purpose of studying local conditions. By this time a well-defined plan has been worked out as to the sequence of various operations, the type, size and location of the mechanical plant; schedules of the materials first needed have been made and orders placed, so that by the time actual operations begin in the field the plans are so matured that there are few false moves. The peak of the superintendent's load is the first few weeks during the organization and starting the work. During this period he should have his full executive force, although each subordinate may not at that time be doing nearly as much as he will be called upon to do later.

PLANNING, ROUTING AND COST ACCOUNTING

During the early stage of actual construction the superintendent makes a careful study of the handling of the work from the beginning to the very end, making a detailed schedule of work along the general lines which had been previously determined in the office.

The job office work is in charge of a chief clerk, who, in addition to overseeing the work of the material clerk and timekeeper, has also charge of the cost-keeping. He figures from the time sheets the cost, of which two records are kept, one for the superintendent's use in card index form, covering every single item on the job, the other considering only the large items, such as concreting floors and columns, placing reinforcing steel and form work for floors, columns and beams. The latter costs are recorded on cross-section paper. These diagrams are posted where the man who has full charge of each item can consult same when convenient for him. The foremen take a particular interest in these. Figures meaning a little larger or smaller cost convey some idea to them, of course, but the meaning of a line traveling upward or downward and above or below a red line representing the desired cost line is grasped very easily. Keeping the foremen keenly awake to the cost of the work they are doing has not been, so far as can be seen, detrimental to their turning out good work. It should always be accompanied, however, by more rigid inspection in the beginning and explained so that they may definitely understand that any lowering of cost shall be considered detrimental to their interest unless the quality remains equal to the standard.

MOVING BOSS AND HIS GANG

The moving boss and his gang are a very important factor in the success of routing. He must be a painstaking, tireless fellow, who has sufficient intelligence to see that the men under his charge do exactly as told, taking the correct materials, carrying them to the proper place and laying them right end to and right side up, as per the written instructions from the routing foreman. The men under his direction must be active, strong and energetic—the pick of the laborers, because they have to do a great deal of moving about and are in small groups or alone; therefore, they are not under the close eye of their foreman. They must be men who will work without being too closely watched. This boss receives instruction as to how each laborer will do his work from the operating foreman.

The method of task and bonus pay is frequently followed on work, and by means of data previously obtained it is possible to ascertain very accurately what the correct best time should be for the making up of any particular panels by a pair of good carpenters. For doing the work in this tasked time an increase over their usual hourly wage is paid of from 25 to 30 per cent. On the erection of the forms a similar method is followed. All material is moved from the stock piles to the point of erection by common laborers, under the leadership of an efficient moving foreman. The foreman receives all instructions on a written slip. The planning department is able at all times to make sure by so doing that the carpenters have the material they want, when they want it, and where it will be most convenient for their use. No carpenters are allowed to carry lumber, but are restricted to doing real carpenter work.

In spite of the wages of carpenters nearly doubling in twenty years while the quality and intelligence of those who do the work is less, because house and finish carpenters will not do this kind of work as formerly, and in spite also of the great advance in price of lumber, combined with a falling off in quality, the unit costs obtained by the above system are materially lower than when the job superintendent was left to himself. The total gain in efficiency is about fourfold.

WEATHER CONDITIONS IN CONSTRUCTION

It is unnecessary to protect form work from the rain, as usually it is only possible to get green lumber, whose tendency is to shrink out of shape rather than swell. Rough concrete never need be protected from the rain before setting, only from the concentrated run-off over some portion of the work which might wash deeply the cement out of a small area.

A troweled finish, however, must be protected against pitting by the rain or damage by concentrated streams. This is usually done by tarpaulin, which consists of 12-oz. cotton duck rendered waterproof by being saturated with "Preservo," after being made into covers 20 ft. square. These are supported by a temporary frame. They are somewhat of an inconvenience to the finishers, and decrease the amount of work which they can do.

If there is to be an unavoidable delay in placing concrete after forms are erected it is wise to protect them from the sun, because they shrink so as to open up cracks, which permit the mortar to escape, leaving a bad surface. Rough concrete does not require any protection from the sun, with rare exceptions. It is usual to cover up a granolithic finish for at least five days. The materials most available and most economically used for this purpose are rough bags, such as come around bales of cotton, or wool, shavings, sawdust, and sand. The object of these is to retain the water which is put upon the surface, which may thus be maintained at a fairly uniform lower temperature than direct sun action permits while setting.

Mr. Wason considers it unwise to spray bare concrete in the hot sun, and the use of roofing paper is but little better, because it retains moisture but a very short time. The water falling on a surface heated directly by the sun chills it suddenly, causing it to shrink, and may cause the very cracks which one is trying to avoid.

The aggregates must be free from frost when mixed. A live steam pipe can be shoved into the sand pile, the escaping steam heating it and removing all frost. The same may be done with the stone, but a canvas should be thrown over the top of the pile to retain the heat, which more readily escapes. Where a considerable amount of heating is provided for in advance, steam pipes are laid on the ground, and stone as received is dumped upon them. Then there is a canvas thrown over to prevent storms getting into the pile, and to retain heat. The frost is thus easily and economically removed.

Salt is frequently used in the water to lower its freezing point. It is seldom worth while to heat the water itself. Little care need be used to prevent mass concrete from freezing, as the frost will usually only strike to a depth of about 1 in. Buildings are inclosed with tarpaulin tied on to an outside staging, and the inclosed space is heated with salamanders burning coke. Sometimes it is possible to use steam.

Frost is removed from form work by the use of salt and steam, and if the concrete surface is left rough it is common to sprinkle the top surface with salt to prevent freezing. In winter it is very common to put the finish on as a separate operation, after the building is inclosed and not as an integral part of the construction, on account of the danger of freezing. When it is put on, it must be kept from freezing for the first forty-eight hours.

The expense of protection against the weather is not very great, and good results can be so surely guaranteed that it is not usual, Mr. Wason states, ever to discontinue work on account of cold weather.

Redressed Granite Blocks

Abstract of Paper by R. H. Gillespie, Chief Engineer, Sewers and Highways, Borough of The Bronx, New York City, Read at Convention of American Road Builders' Association Dec. 9-12, 1913

FOR repaving purposes existing granite blocks, originally laid on a sand foundation, have an economic value. In 1908 the suggestion was made to the authorities of the Borough of The Bronx, New York City, as to the advisability of making use of the old granite blocks by splitting and redressing them. Strange to say, the person making this suggestion was a paving contractor, largely interested in granite quarries. The scheme met with approval and a contract was awarded for repaving Webster Avenue from 165th Street to 171st Street, with the result that an excellent pavement was obtained at very low cost. There has been practically no maintenance cost since the contract was completed, and the pavement at the present time is in very satisfactory condition.

The blocks laid on sand, under the old specifications, are in most cases fully up to the length specified; in fact, a considerable proportion run from 12 to 14 in. in length and are rarely less than 7 in. in depth. The splitting and dressing consists in breaking in two blocks 11 in. or more in length, using the broken face as the head and dressing the ends and sides for ½-in. joints. The finished blocks are from 6½ to 8 in. long, 3½ to 4½ in. wide, and 5½ to 6½ in. deep. Blocks shorter than 11 in. are reheaded where necessary, dressed to lay the required joints, and as a rule are used along the street railway tracks. The splitting and dressing are done on the street by cutters who receive about 1½ cents for each redressed block. Each produces from 450 to 600 blocks per 8-hour day, depending partly on his skill and speed and partly on the character of the granite and condition of the blocks. As the blocks are dressed they are piled along the sidewalk until the concrete is in readiness for the pavement.

The blocks are laid in the usual manner, in rows, at right angles to the curb line on a 6-in. 1:3:6 concrete foundation with a 1½-in. sand cushion. Up to Nov. 15, 1913, 207,150 sq. yd. (or 7.96 miles) of this type of pavement had been laid in the Borough of The Bronx, all of it with vertical joints filled with Portland cement grout, at an average cost of $1.21 per square yard, exclusive of concrete base, as compared with an average cost of $3.20 per square yard for new improved granite block exclusive of foundation.

NEW YORK'S GRANITE-BLOCK PAVEMENTS

At the beginning of the year 1913 there existed in New York City 312 miles of granite block pavement. About half is old-style granite blocks on a sand foundation, distributed as follows: Manhattan, 406,075 sq. yd., or 18.6 miles; Brooklyn, 1,149,323 sq. yd., or 73.9 miles; Bronx, 683,835 sq. yd., or 28.3 miles; Queens, 277,800 sq. yd., or 25 miles; Richmond, 41,582 sq. yd., or 2.4 miles—a total of 2,558,615 sq. yd., or 148.2 miles. This represents over fifty million granite blocks, nearly all of which are suitable for redressing, and when so redressed and relaid will produce a pavement that for cleanliness, smoothness, adaptability for heavy traffic, and durability is practically equal to the new granite pavements laid under the present improved specifications and at considerably less than half the cost.

During the past four years all the improved and redressed granite pavements in The Bronx have been laid with joints filled with Portland cement grout, while in Manhattan and the other boroughs they have been filled for the most part with paving cement or paving cement and gravel. Under like conditions a well-grouted granite pavement will give better results than one where paving cement and gravel are used. The grouted pavement is more easily cleaned, is apt to shed water more readily, is slightly smoother, and there is less tendency for the blocks to "turtle-back." There is one temporary but serious objection, while it lasts, to the grouted pavements—interference and inconvenience to business interests along the line of the street due to the time that the street must be kept free from traffic while awaiting the setting of the grout. This time should be, under the most favorable conditions, not less than one week. Still it is quite practicable to pave one-half of a street at a time, and thus to some extent minimize this objection.

For streets which are called upon to accommodate a large amount of heavy commercial traffic the pavement of the granite-block type (whether new or redressed, grouted or tarred) under the present specifications will prove economical and generally satisfactory.

AN AQUEDUCT 135 miles long is in course of construction in the southeastern part of Italy. It will be completed in 1916, and will supply the cities and districts of Foggia, Bari and Lecce in the Province of Apulia with water for domestic use. The total length of the distribution mains will be 1430 miles and the area served will comprise 3,500,000 acres. The aqueduct is constructed through a mountainous region, necessitating numerous bridges and siphons. Some of the bridges have spans 700 ft. long.

Effect of Hydrated Lime on Portland-Cement Mortars

Changes in Physical Characteristics Determined by Tests, with Curves of Results

By HENRY S. SPACKMAN
President, Henry Spackman Engineering Company, Philadelphia

CONSIDERED from the standpoint of application by trowel the greatest defect of Portland-cement mortars is their lack of plasticity. To overcome this, and also to increase the impermeability, it is becoming quite customary to add hydrated lime cement to mortars used for plastering, stucco or bricklaying. With the growth of this practice the question arises: What, if any, is the effect of such addition on the physical characteristics of the hardened mortar? To this question the investigations described in this paper may give a partial answer.

As the standard methods of testing cement are directed primarily to a determination of the quality of the cement, and not the strength of mortars made from it under the varied conditions found in construction, it was decided to depart from the standard practice in the quantity of water used in gaging the mortar, the manner of storing the test pieces, and the use of standard sand.

The cement used was a typical Portland cement, made by intimate mechanical blending of equal parts of four well-known brands of Portland cement. These cements had been shown by previous tests to be normal.

Two lots of hydrated lime were used, one being a high calcium hydrate and the other a magnesian hydrate. They were prepared in the same manner as the cement—by intimately mixing several well-known brands of each class.

The sand used was a washed Jersey gravel, of better quality than that ordinarily furnished on construction work in Philadelphia and its vicinity.

The typical cement met all the requirements of the standard specifications of the American Society for Testing Materials, and the hydrated limes met the requirements for building hydrates contained in the proposed specifications for lime of the National Lime Manufacturers' Association.

Proportions were made by weight. Tensile tests were made on standard briquettes. The results given are in pounds per square inch, and are the average of five test pieces. All test specimens, except where specifically noted otherwise, were mixed to working consistency, enough water being added to give a mortar sufficiently wet to be troweled or poured. This necessitated the use of about 50 per cent more water than is required to produce normal consistency.

Four sets of test pieces were made from each mixture—one set being stored under water in the laboratory in the usual manner, one set stored in air in a room, one set stored out of doors, exposed to the elements, this exposure being especially severe, as the specimens were placed on a tin roof, exposed to the direct rays of the sun, full force of storms and all variations in temperature; one set was stored alternately two weeks under water and two weeks in air in a room.

TESTS OF CEMENT MORTARS

The first test—the results of which are shown in Fig. 1—was made to compare the strength developed by straight Portland cement mortars when gaged to normal consistency and to working consistency, and shows a decrease in the strength developed under tension by the mortar gaged to working consistency, although this reduction in strength is not as marked as would have been the case if the sand had not been of such good quality.

The series of tests 2—the results of which are shown in Fig. 2—was made to determine the effect of the different exposures on cement and sand mortars. They indicate a marked falling off in strength under tension for test specimens stored in air in a dry room and a considerable falling off in the strength developed under tension for specimens exposed out of doors, and alternately in water and air. While it is unwise to draw positive conclusions from a single series of tests, the fact that the marked reduction in strength noted in the test specimens stored indoors in air under tension is found to persist throughout the investigation with all mixtures leads us to believe that lower strength will be always characteristic of such exposures.

TEST OF MORTARS CONTAINING LIME

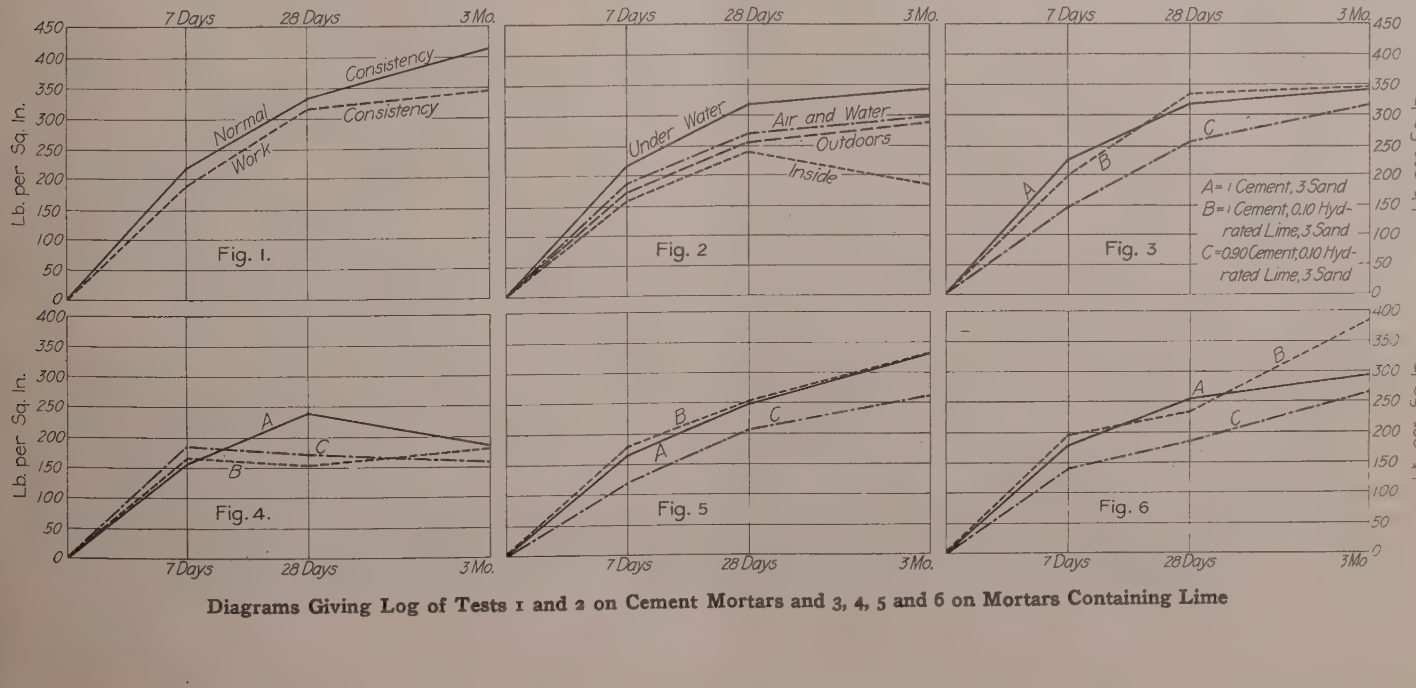
The curves shown in Figs. 3, 4, 5 and 6 are plotted from the average obtained from two sets of specimens, one made from high calcium hydrate and the other from magnesian hydrate. The curves obtained by plotting the results of tests where the different kinds of hydrate were used ran so closely together that to avoid crowding it was decided to combine them.

Tests 3, 4, 5 and 6 were made to determine the effect on the strength of the mortars under different conditions of exposure of the addition of hydrated lime, which in one case amounted to 10 per cent of the weight of the cement—the mixture being 1 part cement, 0.10 part hydrated lime and 3 parts sand. In the other case a substitution of 10 per cent of hydrated lime for 10 per cent of the cement was made—the mixture being 0.90 part cement, 0.10 part hydrated lime and 3 parts sand.

The effect of the addition of hydrated lime on the strength of Portland cement mortars exposed under water was the subject of test 3. The results are shown in Fig. 3.

It is interesting that where the lime forms in addition to the cementitious material the strength is slightly increased under tension for periods of 28 days and 3 months. Where the lime is substituted, though the strength developed at periods of 7 and 28 days, strength is considerably lower; at the 3-month period the reduction in strength is much less.

Fig. 4, plotted from test 4, shows the effect of the addition of hydrated lime on the strength of Portland-cement mortars exposed to air indoors, without contact with water other than the moisture carried by the air. This exposure is characterized by a marked reduction in strength of the cement at the 7 and 28-day periods and as compared with storage under water, and a decided falling off in strength between the 28-day and 3-month periods, contrasting with the continuous gain up to the 3-month period of the same mortars when the



Diagrams Giving Log of Tests 1 and 2 on Cement Mortars and 3, 4, 5 and 6 on Mortars Containing Lime test specimens were stored under water, the strength developed by the test pieces stored in air being slightly more than half of similar test pieces stored under water. The mortar to which hydrated lime was added shows a little greater strength at 7 days than when test pieces are stored under water, but the strength developed at 28 days and 3 months is much less, although the mixtures containing lime do not show as marked a drop at the 3-month period as do the 1:3 cement mortars.

The series of test 5, plotted on Fig. 5, shows the effect of the addition of hydrated lime on the strength of Portland-cement mortars exposed in air out of doors, subject to the action of the elements, and corresponds to the exposure to which such mortars, when used as stucco, would be subjected. This test shows a slight increase in strength resulting from the addition of 10 per cent of hydrated lime to a mixture of 1 cement and 3 sand. Where 10 per cent of the lime is substituted for 10 per cent of the cement there is a reduction in strength at the 7-day, 28-day and 3-month periods, as compared with the strength developed by the 1:3 cement mortars.

Addition of hydrated lime has an effect on the strengths of Portland-cement mortars exposed alternately to submergence in water and to air, as shown in Fig. 6, containing the data of test 6. The general behavior of the test specimens under this exposure corresponds to that when exposed either under water or out of doors. The addition of hydrated lime results on the average in a slight increase in strength, while the substitution of hydrated lime for Portland cement shows a decrease in strength at the 7 and 28-day periods, but at the 3-month period the curves approach each other.

CHANGES IN VOLUME

A series of tests was also undertaken to determine the effect of the addition of lime on the change in volume of the mortars under different conditions of exposure of the test pieces. The cement, hydrated lime and sand used were the same as for the tensile tests. Test specimens 10 cm square and 1 m long were molded from the various mixtures, sufficient material being mixed to allow of all test pieces made from each mix being cast at one time. Copper points were cast in the center of these specimens and a reading taken four hours after molding with a micrometer reading to 0.0001 in. This first measurement was considered the original length of the specimen. These test pieces were allowed to remain forty-eight hours in the mold, then removed, and the test pieces remained two days more in air, after which they were exposed in the same manner as the briquettes. One set was placed under water, one set in air indoors and one set in air out of doors.

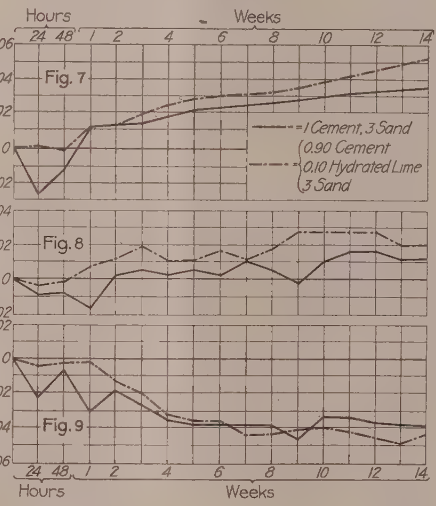
The plotted lines in Figs. 7, 8 and 9 show the calculated changes in volume in 0.01 ft. on a length of 100 ft. All measurements below the heavy line are minus and indicate contraction. All measurements above the heavy line are plus and indicate expansion, the measurements from which the lines were plotted being the average of two or three specimens for each exposure for cement mortars and from four to six specimens for those having hydrated lime added. Changes in volume of test specimens stored under water after exposure for 48 hours in the molds and 48 hours stripped in air to allow them to become sufficiently hard to be handled are plotted in Fig. 7. This exposure is characterized by a practically continuous expansion from the time of submergence up to the 3-month period.

Test specimens stored in air, exposed to the elements, had a change in volume as shown in Fig. 8. These curves indicate that while there is alternate contraction and expansion—probably due to the variation in the moisture content—the general trend is toward a constant increase in volume.

Volumetric changes of test specimens stored in air indoors took place as shown in Fig. 9. The curves indicate a more or less constant shrinkage up to the 3-month period of mortars exposed in air, protected from moisture other than the humidity in the air.

CONCLUSIONS AS TO VOLUMETRIC CHANGES

In considering these three sets of curves it is to be noticed that there is a marked shrinkage of the 1 cement and 3 sand mortars at the 24-hour period—probably due to the loss of excess water used in gaging, followed by an increase in length at the 48-hour period, probably caused by the expansion of cement in hydration. From the 48-hour period there is a more or less constant expansion for the 1 cement and 3 sand mortars, when the exposure is such that water can be supplied to them, and a shrinkage where the exposure is such that no water comes in contact with them.



Tests 7, 8 and 9, Giving Volumetric Changes

Where hydrated lime is added the test pieces remain practically constant in volume up to the 48-hour period, and tests 7 and 8, which represent the normal exposures of mortars, show much less shrinkage than the Portland-cement mortars, although their ultimate expansion is greater. The fact that the test specimens remain practically constant in volume for the first 48 hours explains the absence or reduction of the tendency to crack noted in practical work, where hydrated lime has been added to the mortars, as during the 48 hours the mortar remains practically without change of volume, and there is opportunity for the cement to obtain sufficient coherence to resist the stress due to change in volume. With the straight cement-sand mortars the marked shrinkage up to the 24-hour period, during which time the mortar is weakest, would tend to form hair cracks, which by forming natural lines of cleavage break up the continuity of the material and reduce its resistance to subsequent strain. It should be stated, however, that while, as shown by the averages, there is a more or less general law covering the expansion and contraction of mortars, there was great variation between the individual test pieces of the several sets, even though the conditions of composition, mixing and subsequent exposure were apparently identical, indicating that the change in volume of mortars is influenced by obscure causes difficult to detect.

A test was also made to determine the effect of the addition of lime on the resistance of mortars to abrasion. Cubes with 6-in. sides were cast from the same mortar used in making the test pieces for expansion. These were stored in water for 3 months, allowed to dry in air for 48 hours, weighed, then placed in a small laboratory tube mill, 12 in. in interior diameter, making about 50 r.p.m., 10 lb. of dried Ottawa sand being placed in the mill with each cube. The mill was revolved for 1 hour. The loss of weight through abrasion was determined, the result being as follows:

Mortars consisting of 1 part cement and 3 parts sand lost 1.50 per cent.

Mortars consisting of 1 part cement, 0.10 hydrated lime and 3 parts sand lost 0.69 per cent.

There was no tumbling of the cube, and the abrasion was confined to the two lower edges in contact with the sides of the mill.

From the above-described tests it would appear that the addition of hydrated lime to cement mortars is to be recommended as, besides making the mortar more plastic and impermeable, its use will probably result in a reduction in tendency of the mortars to shrink and crack, greater durability, and probably an increase in strength beyond that noted in the laboratory tests, as the greater plasticity will permit of better work being done by the artisans.

Service Records of Metal Flumes

To determine how metal flumes behave under operating conditions the U. S. Reclamation Service in August, 1913, issued a circular letter asking seven questions regarding galvanizing, rusting, use of paint, keeping joints water-tight, depth of clearance above the water line, erosion by sand where the velocity is high, and maximum limit of velocity in sandy or silty waters. Answers were received from the Orland, Uncompahgre, Boise, North Platte, Carlsbad, Belle Fourche and Shoshone projects. All flumes were of the Maginnis type except one at North Platte which was of the Hess type. These flumes have been in operation from one to four years, averaging three years in service. The answers, summarized, were as follows: Galvanizing is proving serviceable; no serious rusting of the metal body has taken place. At Uncompahgre some sections have failed. Painting is not desirable. At North Platte the experience is that bolts and nuts should be painted. There is little or no difficulty in keeping joints water-tight. At Boise it was found that temperature changes made it necessary to tighten joints each season. The Hess flume at North Platte showed that joints calked with fiber cement were tight but that riveted joints gave trouble. The flume projects from 2 to 12 in. above the water line, averaging 6 in. Sand does not seriously cut the flumes where the velocity is high (the contrary has been experienced at the Uncompahgre).

Letters to the Editor

Extra Top Width for New Railroad Embankments

SIR: May I add a few words to the current discussion of embankment slopes and its relation to shrinkage? [See Engineering Record, Oct. 25, 1913, page 459, and Nov. 22, page 589.] Common sense and the elimination of as many chances for error as possible are the groundwork for efficiency in engineering. Much of our field work must be done by men fresh from school or newly promoted to instrument work, and even to make the crown width in odd feet, instead of even, as was done here, adds a complication that makes the percentage of error much larger in cross-sectioning. I consider the addition of a shrinkage height to increase slope width unnecessary, as in settling vertically the embankment usually spreads at the bottom. The table of slopes recently given may have the effect of getting a permanent roadbed of the ideal section, if properly and promptly sodded when the shrinkage has taken place, and if the rains and frosts give it a chance.

In grading 15 miles of double-track roadbed on new location across the Kotas of eastern South Dakota proper shrinkage allowance was a problem. The profile shows mainly short deep fills, ranging from 25 to 45 ft. and longer, more moderate cuts, with a 1 per cent compensated grade, rising west, unbroken. Grading was all steam shovel and grading machine-dump wagon work. I could get no data as to shrinkage in this material, except generalities from contractors, and used the experience gained in fifteen years' service from Florida sand to Indiana shale as a guide, making a 5 per cent vertical allowance for team haul and 10 to 12 per cent for steam-shovel fills, unless the breaking up of the material or character of foundation justified variance. As usual, I required contractors to make the slopes full to cross-section stakes set, without allowance for shrinkage, and to carry the vertical height up to the shrinkage point with full width of roadbed and generous measure. When work is paid for in excavation this is no hardship on the contractor. The slope of the newly finished dump is, of course, steeper than the $1\frac{1}{2}$:1 specified.

Analysis of the final estimates shows that not enough shrinkage was allowed on this work. The material, even in borrow pits, below the top soil is a blue clay with many boulders from the size of a man's head to that of a wagon body and a gumbo-like material with many of the characteristics of hardpan, and did not break up as expected under team haul. The final figures show excavation quantities running very close to embankment quantities, when they should overrun from 6 to 8 per cent.

In this case, however, no damage was done, as track followed grading so closely that some of the very short, deep fills show quite a hump, and had full shrinkage been placed it would have been necessary to plow off in many places before track could have been laid. Then, as the total length of embankment on the 15 miles is much less than the excavation, the expense of raising on gravel to the final grade will not be great compared to the inconvenience of operation over a bumpy track.

Over the first fill, not much more than a year old, transcontinental trains have been running since August, and riding better than on the old track.

BUTLER SMITH,
Resident Engineer, Chicago, Milwaukee & St. Paul Railway.
Milbank, S. D.

Collapse of Concrete Building at Cedar Rapids, Iowa

SIR: In making further comments upon the Stark-Lyman building failure at Cedar Rapids, Iowa [see Engineering Record, Nov. 22, 1913, Current News Section; Nov. 29, 1913, page 598; Dec. 20, page 705, and Dec. 27, page 714], I wish to call your attention to an article published by the Engineering Record of Jan. 18, 1913, page 66, under the title "Influence of Temperature on Concrete." In this article it is stated that "it is not uncommon in building construction to get an arrangement of form supports for new floors which, during the pouring of the concrete for the floor above, will impose a load on the supporting floor considerably greater than the full load for which it was designed. If the supporting floor is only 7 or 8 days old it is able to carry little or no external load and the weight of the green floor must be transferred to the second floor below. If this second floor is only 15 or 16 days old, it probably can carry only little external load."

This condition is or should be common knowledge with experienced builders. Yet, what have we in this Cedar Rapids failure under the supervision of an "experienced" superintendent? While the exact causes of this failure have not yet been recorded, certain conclusions can easily be drawn. The structure was designed for light live loads with high unit stresses for the materials. Erection took place during cool (not cold) weather, with no attempt being made to heat materials. Loads on form supports or posts were not well distributed.

The fifth floor, the last from which forms were removed, was placed 32 days before the failure. During these 32 days there were 21 nights that the thermometer recorded 32 deg. Fahr and below, and the average of the mean daily temperature for the period was 39 deg. Fahr. The sixth floor had been completed 22 days before failure with still lower average temperature. The seventh floor was poured 13 days before the failure and the roof was being poured at time of collapse.

According to the diagrams of strength and suggested method of determining, roughly, the strength of concrete in cool weather, outlined in the Engineering Record article mentioned above, the fifth-floor concrete would have reached a compressive strength of nearly 1200 lb. per square inch. The sixth floor would have developed a strength of about 1000 lb., and the seventh floor about 950 lb. per square inch.

The dead load on the floor slab was about 67 lb. per square foot, and that of the roof slab about 62 lb., which, with workmen, wheelbarrows of material and saturated forms, could easily be increased to 95 lb. per square foot over a small area. A little more than one-half of a roof panel was poured when collapse occurred. Form posts were spaced on 4-ft. centers each way; thus a single post would receive from the roof 1520 lb. or more.

Of the four posts parallel with the ribs, and supported by one rib on floor below, two would be fully loaded and two partly loaded (as the roof was only partly poured), giving at least 3800 lb. on a single rib. It will be recalled that the floor construction is combination tile and concrete ribs and that small blocks only were placed under posts. The seventh floor is hardly able to support its own dead weight and the sixth floor, we will assume, able to support itself. The saturated forms and rubbish for these two floors will add, say, 18 lb. per square foot each. Thus, as a minimum condition, we will get an accumulation of loads to be supported on the fifth floor of 3800 lb. from roof plus 2300 lb. from forms and possibly one-fourth of seventh floor, or 1070 lb., making a total external load of 7170 lb., or 2.8 times the load for which the floor was designed, this supporting floor itself having reached only a little over one-half of its full strength. It is not strange that it failed. The strange thing is that such a condition was permitted to exist.

It should be repeated again and again that the elements of concrete are cement, stone, sand, water and heat, all correctly proportioned and thoroughly mixed. That nature often gratuitously supplies the heat is no reason for omitting it when she withdraws her benefaction.

If materials had been heated in this case, as an experienced contractor would do—if only as a consideration of economy—then the chances are there would have been no failure despite other omissions.

The point I wish to raise again, and the necessity of which this disastrous failure distinctly emphasizes, is the necessity of more knowledge of the action of concrete under cool-weather conditions. There is sufficient present knowledge to have avoided such a disastrous failure as the one mentioned, yet there is great need of more reliable information as to the effect of low temperature upon the setting action of concrete. At present if the thermometer lurks around 40 or 45 deg. while concreting is in progress we have to guess at its strength at different periods of elapsed time. No amount of "experience" is adequate here for all conditions, unless this experience is fortified by experimental knowledge.

There was a man of unusual experience in charge of this unfortunate building and yet there occurred the most disastrous failure in concrete-building construction. Much of his experience, however, had been with heavy, massive work where a misguess is not so serious.

Some of our material-testing laboratories should take this matter up and execute a series of experiments wherein the temperature element can be controlled and made the variable element, all other features being made constant. This would require a large number of tests to make the results general and reliable for use under the varying conditions of construction.

In illustrating the use of the table for strength given in the article above mentioned let us take the sixth-floor concrete of this building, which was 22 days old at time of failure. Concreting was completed on Oct. 23. The mean temperature for Oct. 23 was 41 deg., following three days whose mean temperature was near 32 deg. or below. Consequently all materials would be thoroughly chilled. Thus we could take from the table on page 68 of the Engineering Record of Jan. 18, 1913, the number representing the first day's developed strength—somewhat less than the number opposite 41 deg. as mean daily temperature —about 37 lb. For the second day the mean daily temperature was 48 deg., and corresponding to this the increment is 100 lb., and for succeeding days the figures are given in the table.

DAILY INCREMENT OF STRENGTH OF CONCRETE

Day after pouring	Mean daily temp., deg. Fahr.	Strength increment, lb. per sq. in.
1	41	37
2	48	100
3	50.5	95
4	34	7
5	34.5	7
6	37	10
7	32	0
Total, 7 days..............		256
8	27.5	0
9	31	0
10	36	4
11	48	12
12	44	9
13	38	4
14	44	6
15	53	10
16	45	7
17	32	0
18	32	0
19	32	0
20	32	0
21	46	7
22	37	3
Total		318
Undeveloped strength brought over and made available from first 7-day interval = (1100 — 256) 0.8 =........		675
		993

As crude as this method is, it is better than a mere guess even by an experienced man. If maximum and minimum thermometers are not available, the average of the 8 a.m. and 8 p.m. temperature readings will generally give results varying only by 1 or 2 deg. from the correct mean.

The formula for strength at the end of seven days as given in the table is as follows: $S_7 = \frac{1}{4} (25t_1 + 25t_2 + 20t_3 + 15t_4 + 10t_5, + 8t_6 + 7t_7)$ where S_7 = compressive strength per square inch at seven days' age; t_1, t_2, t_3, etc. = mean daily temperatures for first, second, third day, etc.

For fourteen days $S_{14} = S_7 + \frac{1}{4} (6t_8 + 5t_9 + 4t_{10} + 3t_{11} + 3t_{12} + 3t_{13} + 2t_{14}) + 8/10 (1100 — S_7)$

WARREN A. HOYT,
Chicago. Consulting Engineer.

Packing-House Floors and Effects of Grease and Water

SIR: The effect of hot lard on concrete described by Mr. J. Norman Jensen in the Engineering Record of Nov. 29, 1913, page 602, calls attention to a difficulty experienced in many packing houses throughout the country where concrete-floor surfaces are subject to the action of grease and water. Concrete-floor surfaces have been laid in rooms where hog and beef fats are rendered, in sausage rooms, and upon slaughtering floors. In a large number of cases they have proved unsatisfactory because of the tendency of the concrete to crack, its difficulty of repair, and the solvent action of grease and hot floor liquids upon it. At the present time it has become a quite general practice to provide a wearing surface of brick, tile or asphalt for such floors in packing houses of the reinforced-concrete type of construction.

Probably in no other type of industrial building do floors receive such severe tests as in a modern packing house, so that the subject of satisfactory floor surfaces is of much concern to owners of such establishments and to Government employees charged with maintaining proper sanitary conditions in them. The large quantities of water used and the wear and tear of truck wheels make it imperative that the floor surface be watertight, impervious to solvent action of grease and hot water and resistant to grinding action. Such floors must also be elastic, easily repaired, smooth and sanitary, and yet offer sufficient foothold for the workmen.

The types of floor in most common use in establishments where Government meat inspection is maintained are wood, brick, tile, asphalt, concrete, terrazzo, stone, and various floor compounds. Wood floors and wood construction throughout packing houses were formerly much used, but owing to rapid deterioration when subjected to the action of water, wood has been largely superseded by more enduring materials. Where a floor may be kept dry and is not subjected to hard usage this material is satisfactory.

Vitrified-brick flooring has generally given good satisfaction and is much used for rooms where slaughtering is done, also in departments where the floor will be subjected to hard wear and the solvent action of grease and hot water. The "half-brick," having a depth of 1¼ in., is usually employed, since the thickness is sufficient and the weight to be carried considerably less than if standard brick were used. Cement mortar or pitch is generally used to fill the joints. The latter has the advantage of making the floor less noisy and more elastic, but it is not as resistant to the action of floor liquids as some other joint fillers. It is important that only the best vitrified brick be used and that the floor be well laid.

Tile is used to a large extent in sausage rooms for floors and walls and in departments where oleo oil and oleomargarine are made. They present a good appearance and resist the action of grease and water, but are not adapted to as hard usage as vitrified brick.

Asphalt floors have been laid very extensively, and in some instances have given good satisfaction, while in other cases, due to poor construction or the severe conditions imposed, they have failed to meet requirements. When well laid they are watertight and lighter than any other types of floor. Many asphalt floors have softened and become sticky in hot weather, so that truck wheels and barrels standing on the floor have sunk into the floor surface. This is also the case in rooms in which a warm temperature is maintained for "seeding" and the like. Asphalt floors in coolers and rooms under refrigeration have generally proved satisfactory.

Concrete floors are satisfactory for many rooms of a packing house when well laid, but are not suitable when called upon to meet the conditions previously described. In buildings recently constructed various waterproofing and hardening compounds have been added to the concrete, but they have not been in use long enough to determine their value.

Terrazzo floors generally give good satisfaction, but their high cost prohibits their use except in rare cases where a high standard of construction is sought.

Stone-slab floors of slate or bluestone are sometimes used for slaughtering rooms and sweet-pickled meat cellars. They possess the advantage of being easily cleaned and durable, but when laid with tight-fitting joints are comparatively expensive.

Many different types of proprietary floor surfaces have been laid in packing houses with various degrees of success. The conditions to be met should be thoroughly appreciated before such surfaces are put down.

The severe conditions imposed upon packing-house floors will be considerably lightened if liquids are taken care of as near as possible at the place where they originate and not allowed to overflow a large part of the floor before reaching an outlet. It is also important that such floors be made self-draining by providing a sufficient pitch to floor drains, and that the drains have proper capacity. Floors having a pitch from ¼ to ½ in. per foot have proved satisfactory in this respect.

Since the meat-inspection law of 1906 went into effect, giving the U. S. Department of Agriculture supervision over sanitary conditions in interstate meat packing establishments, as well as the inspection of animals and meats to be used for food, no fewer than one hundred and forty-five of the packing houses now under inspection have been newly constructed, and more than 80 per cent of these are of reinforced concrete or of the slow-burning mill type of construction.

GEORGE H. SHAW,
Sanitary Engineer, U. S. Department of Agriculture, Bureau of Animal Industry.
Washington, D. C.

Emergency Power from Second-Hand Locomotives

SIR: The problem of replacing an old, inadequate battery of boilers with a new one of greater capacity without interrupting operation was recently encountered by this company. An estimate from the local power company showed electric power to be of prohibitive cost. The idea of utilizing locomotives for the purpose was then studied. The location of the plant, on the main line of the Pennsylvania Railroad, made feasible the storage of locomotives on a long freight siding.

After some difficulty in finding engines with practically small boiler capacity, two "American" locomotives were obtained from the railroad. The process of boiler substitution was simple. The two old locomotives, whose connecting rods and valve gears had long been disconnected, were hauled to a convenient point on the siding, after their tenders had been uncoupled; their throttle valves were closed, and a connection piped from their auxiliary domes, over the fireboxes, to the main steam lines in the plant. Their positions, back to back, with an elevated platform erected between them, allowed sufficient space for two firemen.

As a matter of fact, this means of steam supply is hardly economical enough to warrant its retention for a protracted period, since the amount of coal consumed per hp-hr. is far greater than the average manufacturing plant can afford; but there is no question that the money for the excess coal consumption, in addition to the moderate rental and a few dollars more for labor, is well spent when there results a continuous steam supply that keeps the plant running.

FLETCHER SCHAUM,
Philadelphia. Schaum & Uhlinger, Inc.

Electrical Equipment for the Chicago, Milwaukee & St. Paul

Motive Power, Substations, and Transmission-Line Construction for 2400-Volt Direct-Current Electrification in Rocky Mountains

AFTER careful consideration the Chicago, Milwaukee & St. Paul Railway has decided to use 2400-volt direct current catenary system for the proposed electrification of its Rocky Mountain division between Three Forks and Deer Lodge, Mont., a distance of 113 miles, corresponding to approximately 168 miles of single track. This covers one freight division.

The trolley will be fed from five substations containing synchronous motor-generator sets, step-down transformers and necessary switching apparatus located at the following proposed sites: Morel, 17 miles east of Deer Lodge; Newcomb, 46 miles east of Deer Lodge; Grace, 63 miles east of Deer Lodge; Piedmont, 78 miles east of Deer Lodge, and one at Three Forks. The sites of these substations may be varied slightly if later investigation shows such changes desirable. These stations will receive energy from the 100,000-volt transmission line of the Great Falls (Mont.) Power Company. No decision has been reached with regard to the type of either the passenger or the freight locomotives. It is probable that twelve locomotives will be required for freight service. The freight locomotives will be required to haul a trailing load of 2500 tons up a 1-per cent grade at a speed of approximately 15 miles per hour. The passenger locomotives will be required to handle a trailing load of 800 tons on level track at approximately 50 miles per hour, and on a 2-per cent grade at approximately 24 miles per hour. The current will be taken by means of roller pantograph collectors. Trains will be heated by means of oil-burning steam boilers.

All the locomotives, both freight and passenger, will be provided with regenerative control. The air brakes will be used only for stops and in emergencies.

SUBSTATIONS

Based upon the investigation of the locomotive performance on the ruling grades in the electrified zone, it has been decided to install in each substation supplying gradients of over 1 per cent a capacity of three 1500-kw units, two being in operation and the third held in reserve. Although the starting of a train calls for practically 100 per cent overload upon the two units in operation, a 200-per cent overload for five minutes' guarantee will furnish ample capacity to start a train of maximum tonnage on a maximum grade.

For gradients up to 1 per cent energy will be furnished from a two-unit substation containing two 1500-kw motor-generator sets, each having a maximum load capacity of 4500 kw for a period of five minutes. It is the intention to use one 1500-kw unit in operation with the second as reserve, to be used in emergencies such as disablement of the operating unit or a congestion of trains requiring them to be operated in fleets.

Basing the substation capacity and location on the foregoing limitations, it is proposed to install three three-unit and two two-unit substations on the 113-mile division between Deer Lodge and Three Forks, Mont. In each case the substation building will be designed to accommodate an additional unit which may be installed when future traffic conditions make it desirable. All substation units are to be of the same size and will comprise a sixty-cycle synchronous motor direct-connected to two 750-kw 1200-volt direct current generators connected in series for 2400 volts. Each motor-generator set will be fed from three single-phase step-down transformers reducing from a transmission potential of 100,000 volts to 2300 volts at the synchronous-motor terminals. Each motor-generator set will be equipped with two exciters, one for the synchronous motor and the other for the fields of the generators, thus making the motor-generator set, step-down transformer and exciting generators, together with the controlling switchboard, a complete unit in itself.

It is proposed to erect the substation buildings of brick on concrete foundations with a concrete roof supported on steel girders which provide a foundation for the overhead high-voltage bus bars. Each building will be equipped with a crane of sufficient capacity to move the heaviest part of the substation apparatus. Transformers will be of the self-oil-cooled type, placed in a roofed transformer room with tracks to facilitate installation and repairs. The accompanying table presents the equipment and capacity of each substation.

SUBSTATIONS AND THEIR EQUIPMENT

Location	Equipment	Total Capacity
Morel	2-1500-kw	3000 kw
Newcomb	3-1500-kw	4500 kw
Grace	3-1500-kw	4500 kw
Piedmont	3-1500-kw	4500 kw
Three Forks	2-1500-kw	3000 kw

Energy will be supplied to the locomotives by means of roller contact with an overhead copper trolley wire located at least 24 ft. above the rail. The trolley wire will be of No. 0000 copper and suspended from a steel catenary cable. This catenary construction will be supported by bracket arms extending from wooden poles, except on the sharper curves, where two poles and span wire construction will be employed. The single pole bracket construction is to be followed wherever possible, because it affords less obstruction to view and is also less expensive than span construction. Where two or more tracks are to be spanned span construction with wooden poles will be employed. Where the number of tracks exceed four, steel construction will be used.

The overhead trolley will be supplemented by feeder copper in order to restrict the energy losses in the 2400-volt conducting circuit to a reasonable amount. However, only a portion of the complete feeder system will be installed until such time as the maximum tonnage of trains has been reached and the frequency of train service more definitely determined. For immediate installation the feeder copper will be as follows: Deer Lodge to Colorado Junction, 750,000 circ. mil.; Colorado Junction to Piedmont, 1,000,000 circ. mil.; Piedmont to Three Forks, 500,000 circ. mil. The details of track bonding have not yet been decided.

The Great Falls (Mont.) Power Company proposes to construct new transmission lines where necessary to deliver electricity to the Chicago, Milwaukee & St. Paul Railway electrified zone. This power will be supplied in about the following capacities: Deer Lodge, 20,000 kw; Butte, 10,000 kw; Three Forks, 3000 kw. This arrangement necessitates building a new duplicate transmission line from Great Falls to Deer Lodge. As the proposed feeding-in points of the Great Falls Power Company do not coincide in all cases with the location of the substations, the railway will install a transmission line to tie in these feeding points to each of the several substation sites. This transmission line will follow the railway company's right-of-way, except at some points where it is possible to cut across the country and save distance.

Owing to the great distance from the right-of-way of the railway company to the source of power at Great Falls, it was found necessary to adopt a transmission potential of 100,000 volts, both for the Great Falls transmission lines and for the single-circuit transmission line on the railway company's right-of-way. This high potential permits a shift in loads to different parts of the system without excessive loss. The transmission line built along the railway company's right-of-way and connecting the several substations will include the 100,000-volt line suspended upon 45-ft. wooden poles by a six-unit suspension-type insulator.

Draining Retaining Walls

IN the extensive retaining-wall construction through the Watsessing depression on the Montclair branch of the Delaware, Lackawanna & Western Railroad, described in the issue of Dec. 20, 1913, page 687, special care was taken to secure ample drainage. The walls were built in 20-ft. sections, without horizontal joints, and with tongue-and-groove vertical joints to impede the flow of water as much as possible. The joints were waterproofed for the full height of wall and for a width of 18 in. on either side of the joint. Burlap and asphalt were the waterproofing materials used, the burlap being placed two ply, with coats of asphalt placed alternately. Gasoline was burned on the concrete surfaces to remove any moisture. Just above the top footing at each joint a 4-in. drain was carried through the wall in the customary manner, but at the inner end of each pipe was set a right-angle elbow, turned upward. Loose rock was then piled around the elbow and up to the full height of the wall in a column about 3 ft. longitudinally and 2½ ft. transversely.

With the use of the elbow for each drain it was thought that the water, trickling down through the rock drain, would come to rest at the bottom, and would gradually deposit its suspended matter around the pipe. When this sedimentation reached the rim of the open pipe it was believed that the water washing over the rim of the pipe would carry the sediment in small amounts entirely through the pipe, thus keeping the drain open longer than if the elbow had been omitted. Eventually, it was figured, the sediment would form a natural funnel at the mouth of the drain.

The arrangement was carried out by Mr. W. H. Speirs, resident engineer, under the direct supervision of Mr. G. T. Hand, division engineer, and the more general direction of Mr. G. J. Ray, chief engineer.

Floating Caissons for Panama Locks

Details of Craft Similar to Those Used at Drydocks to Form Dam and House Pumps for Unwatering Lock Chamber

A FLOATING lock-entrance caisson, similar to those used at the entrances to drydocks, is under construction by the Union Iron Works of San Francisco for emergency use at Panama. The vessel is described and illustrated in the "Canal Record," from which this article was prepared. The caisson in position will span a lock width of 110 ft., and will permit the unwatering of the lower Miraflores lock at high tide, when the depth is 61 ft. The pumping machinery for unwatering caisson and lock chamber will be within the caisson. The caisson will have a draft, light, of 32 ft. to allow its convenient handling through the locks, and will fit any of the locks. When floated into place at the lock entrance water will be let into the hold until it sinks, after which the water will be pumped from the lock chamber. When this chamber has been refilled the water will be pumped out of the caisson hold and the caisson will be floated away.

MAIN DIMENSIONS

The vessel is 112 ft. 6 in. long. It is approximately pear-shaped in cross-section, the maximum width of 36 ft. being about one-third of the way up from the keel, and that at the top about 18 ft. As it is desired to have the side walls of the locks carry practically all the static load from the caisson when it is supporting the water pressure, there will be a number of horizontal decks and end breasthooks to carry the load to the vertical ends; and a system of vertical framing will transmit the panel loading to the decks and breasthooks.

Nine cross-frames, spaced about 12 ft. apart and extending the whole height of the caisson together with intermediate frames at intervals of about 2 ft., will constitute the transverse framing system. At each end one of the cross-frames will be watertight, forming collision bulkheads, which will also serve as trimming tanks to maintain longitudinal stability and cause the caisson to settle on an even keel. The other seven cross-frames will have apertures in their lower sections to allow control of the water within the caisson and regulation of the depth of immersion. A longitudinal bulkhead from keel to operating deck will extend the entire distance between collision bulkheads. Its lower part will be sufficiently watertight to divide the free surface of the water ballast and increase the stability against lateral motion.

There will be five decks, as shown in the drawings. The lower two will be entirely plated over, with the exception of manholes and hatches. The middle or operating deck will be made absolutely watertight; it will support the pump motors, switchboards and registers. The plate-stringer deck, 49 ft. above the base line, will be an open truss with diagonal bracing. The top deck will be plated over.

Six plate breasthooks will be built at each stem of the vessel at intervals between the decks. They will transmit the end shears from the decks to the vertical girders. One of the breasthooks, situated 31 ft. above the base line, will be watertight and serve as the bottom for the end trimming tank. At the same level as the breasthooks will be longitudinal intercostals riveted to the transverse frames and the sheathing.

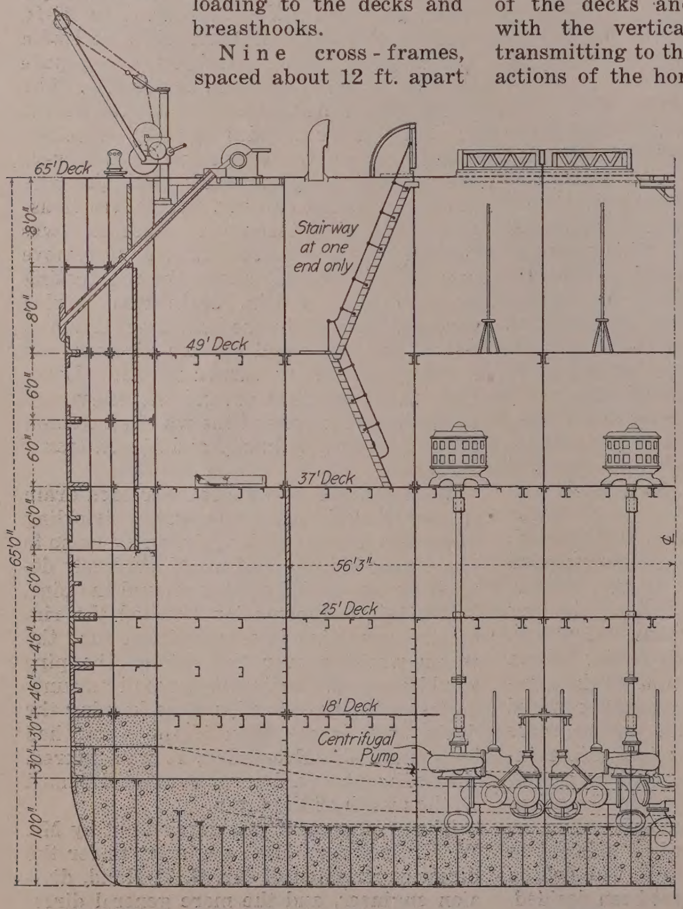
Steel plating will sheathe the entire skeleton. End-reaction castings will provide connection of the decks and breasthooks with the vertical girders for transmitting to the latter the reactions of the horizontal forces. British Guiana greenheart cushions will be fastened along the exteriors of the ends and keels. Fixed ballast of pig iron and concrete will be placed in the bottom of the hull.

PUMPING PLANT

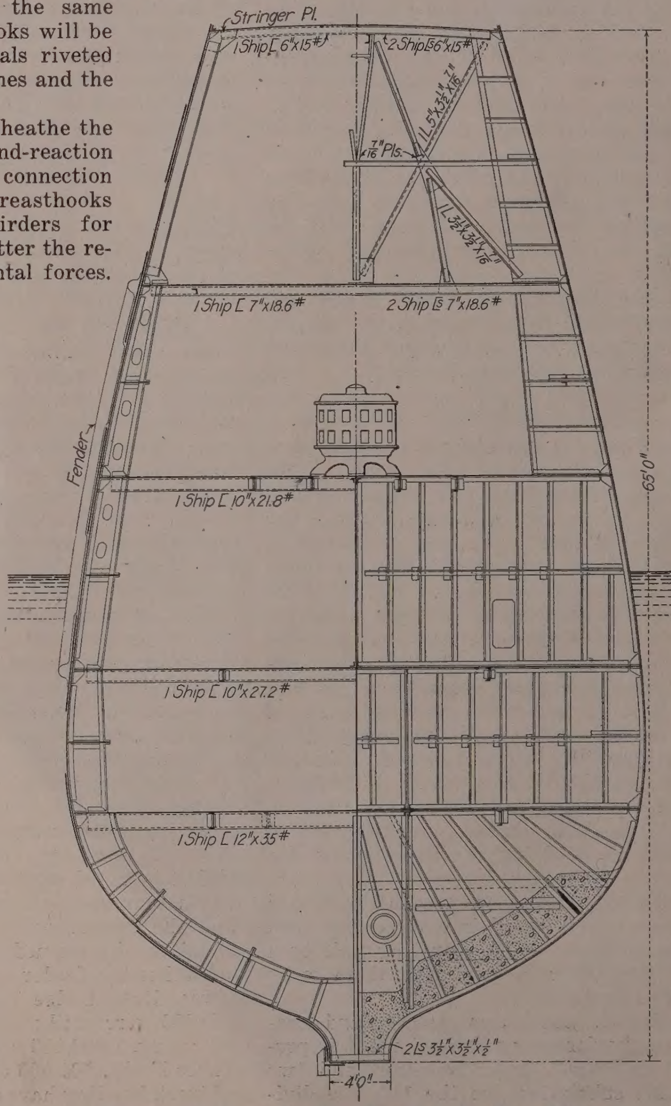
The main pumping system will consist of four vertical-shaft centrifugal pumps with 20-in. discharge and 22-in. suction. It must pump out in not more than twenty-five hours all water in the upper and lower chambers of one flight of Miraflores locks between mean sea level and the top of the sill of the lower chamber, which is at elevation —50. This will amount, including leakage, to about 10,285,000 cu. ft. The average discharge will be about 13,000 gal. per minute for each pumping unit.

Inasmuch as the sill for the caisson is higher than the level of the floor, suction extension pipes are to be provided to cross the sill on the bottom of the chamber, to allow complete unwatering. The suction extensions will be lowered by cranes on the deck and attached from a pontoon similarly handled.

The caisson is expected to be completed about September, 1914. Its fabrication and erection are being supervised at the plant of the contractor by Mr. Lewis A. Mason, assistant engineer of the Isthmian Canal Commission, who was associated with Mr. Henry Goldmark, designing engineer, in working out the design, plans and specifications.



Longitudinal Half-Section, Showing Pumps and Ballast



Transverse Cross-Section, Showing the Five Docks